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NILAN RESERVOIR

EAST DAM and NORTH DAM

MANUAL FOR
OPERATION AND MAINTENANCE

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PROJECT DESCRIPTION

OVERVIEW

Nilan Reservoir is owned by the Montana Department of Natural Resources and Conservation (DNRC) and is managed by the State Water Projects Bureau (SWPB) of the DNRC. The Nilan Water Users Association (herein called the "association") operates and maintains the dams.

This off-stream reservoir is located in Lewis and Clark County, approximately 7 miles west of Augusta, Montana (see Figures 1 and 2). The project consists of a North Dam controlling releases to the North Canal and an East Dam controlling releases to the East Canal. Figure 3 provides a general layout of the dams, spillway and outlet works. Figures 4 and 5 show the location of the monitoring wells at the East and North dams.

Water from the reservoir is primarily used for irrigation water supply. The reservoir is also used for water-based recreation.

SUPPLY CANAL

Water diverted from Smith Creek is conveyed via the Smith Creek supply canal to a diversion on Ford Creek. The conjoined Smith Creek canal and Ford Creek waters are then delivered to the Nilan Reservoir by the main supply canal. The Smith Creek canal is 3.73 miles long and has a design capacity of 200 cfs. The main supply canal is 1.47 miles long and has a design capacity of 300 cfs.

The Smith Creek canal was breached by a landslide in 1953 and was restored in 1954. The right berm of the canal collapsed at a point along its easternmost reach in 1964 and was repaired. Two undersized culverts were installed in the eighties. A major canal maintenance operation was undertaken in the spring of 2005. The undersized culverts were replaced with larger culverts; sediment was removed from the canal prism, and vegetation was removed from the bottom of the canal.

EMBANKMENT

Both earthfill dams were completed in 1951. Nilan East Dam is 51 feet high and 1,010 feet long with a crest width of 20 feet. County road S-435 crosses the crest of the East Dam.

The North Dam is 54 feet high and 530 feet long with a crest width of 20 feet. Appurtenant to the dam is a 1,300-foot-long dike, which extends generally southeast from the east abutment along a low area in the topography. The dike has the same crest elevation as the dam and has a maximum height of 8 feet, with the same side slopes and crest width as the dam.

In the spring of 1999, several small and one large (6 feet by 8 feet) sinkholes were discovered along the upstream toe of the East Dam embankment. Repair of the sinkholes started on April 27, 1999, and was completed on May 17, 1999. The repairs consisted of removing the existing native material, placing a compacted base of granular material, installing a geotextile fabric on the excavated face of the dam, placing a bentonite liner (GCL) around the perimeter and bottom of the excavation, and then replacing and compacting the native clay material. A compacted granular layer of sand and gravel was placed on top of the native clay material, and then a geotextile fabric was placed over the area. Riprap was placed on the geotextile blanket to protect the repairs from erosion.

In the fall of 1999 after the reservoir had been substantially lowered due to irrigation withdrawls, another sinkhole was discovered immediately north of the previous repair. Work to repair this sinkhole started on November 2, 1999 and was completed on December 18, 1999. This repair was tied into the previous work. The repair extended northerly from the right abutment for approximately 320 feet and extended about 90 feet from the upstream toe of the dam toward the lake. This second larger repair effort was similar in design to the previous effort. Slight modifications were made to increase slope stability above the GCL.

OUTLET WORKS

The outlet works at each dam consists of an inlet structure, reinforced concrete tunnel, control tower with gatehouse, and an outlet structure. The intake conduit and outlet conduit are a four foot diameter, cast-in-place, reinforced concrete tunnel. The control tower at each dam consists of a double chambered wet tower with a 48-inch square slide operating gate and a 48-inch square emergency slide gate. Controls for both gates are at the top of the tower.

A 6-inch diameter air vent pipe provides air to the outlet conduit at each dam. The air vent is anchored to the outside of the downstream wall of the wet tower and branches at the conduit to provide two air supply points. At the dam crest, the air intake in inverted 180 degrees to protect against plugging of the vent.

The maximum capacity of the East Dam outlet is 385 cubic feet per second (cfs) and the maximum capacity of the North Dam outlet is 395 cfs.

SPILLWAY

The spillway is located in a natural swale approximately 320 feet northwest of the north abutment of the East Dam and releases water into the Elk Creek drainage. The water flows across county road S-435 when the spillway is operating. The spillway has a concrete control section which functions as a low drop structure, 1.8 feet high, 72 feet long and 0.75 feet wide. The maximum capacity of the spillway is 8,620 cfs.

DRAINS

East Dam: There are no known internal drains at the East Dam.

North Dam: There are two toe drainpipes that exit into each side of the outlet channel, approximately 25 feet downstream of the outlet. These two drains are not shown on any of the design drawings for the North Dam. The COE Phase I Inspection Report, July 1981, reported that a May 18, 1953 report commented about some seepage and extending the right drain by 25 feet and constructing an additional drain on the flat below the hill. This indicates that the drains were part of the original construction of the dam. The flow in the drains varies depending upon the reservoir elevation. In 1999, the water users built a fence around the area to keep cattle from damaging the drainpipes and the toe of the dam.

DELIVERY CANALS

East Canal: Water from the East Dam is released into the East Canal, delivering water into Smith Creek of the Elk Creek basin. The canal is 5.2 miles long and has a capacity of 74 cfs. This canal has been disposed to seepage and has been treated with bentonite, and in 1992 approximately 8,900 feet of the canal was lined with a plastic canal liner.

North Canal: Water from the North Dam is released into the North Canal, which delivers water in the Willow Creek basin. The canal is 2.05 miles long and has a capacity of 75 cfs. The canal has required substantial maintenance to repair problems of erosion and seepage.

Florence Canal: Water deposited from the East Canal into Smith Creek is diverted into the Florence canal, which is 16.25 miles long and has a capacity of 85 cfs. Ownership of the Florence Canal was transferred to the Nilan Water Users Association on July 31, 1995.

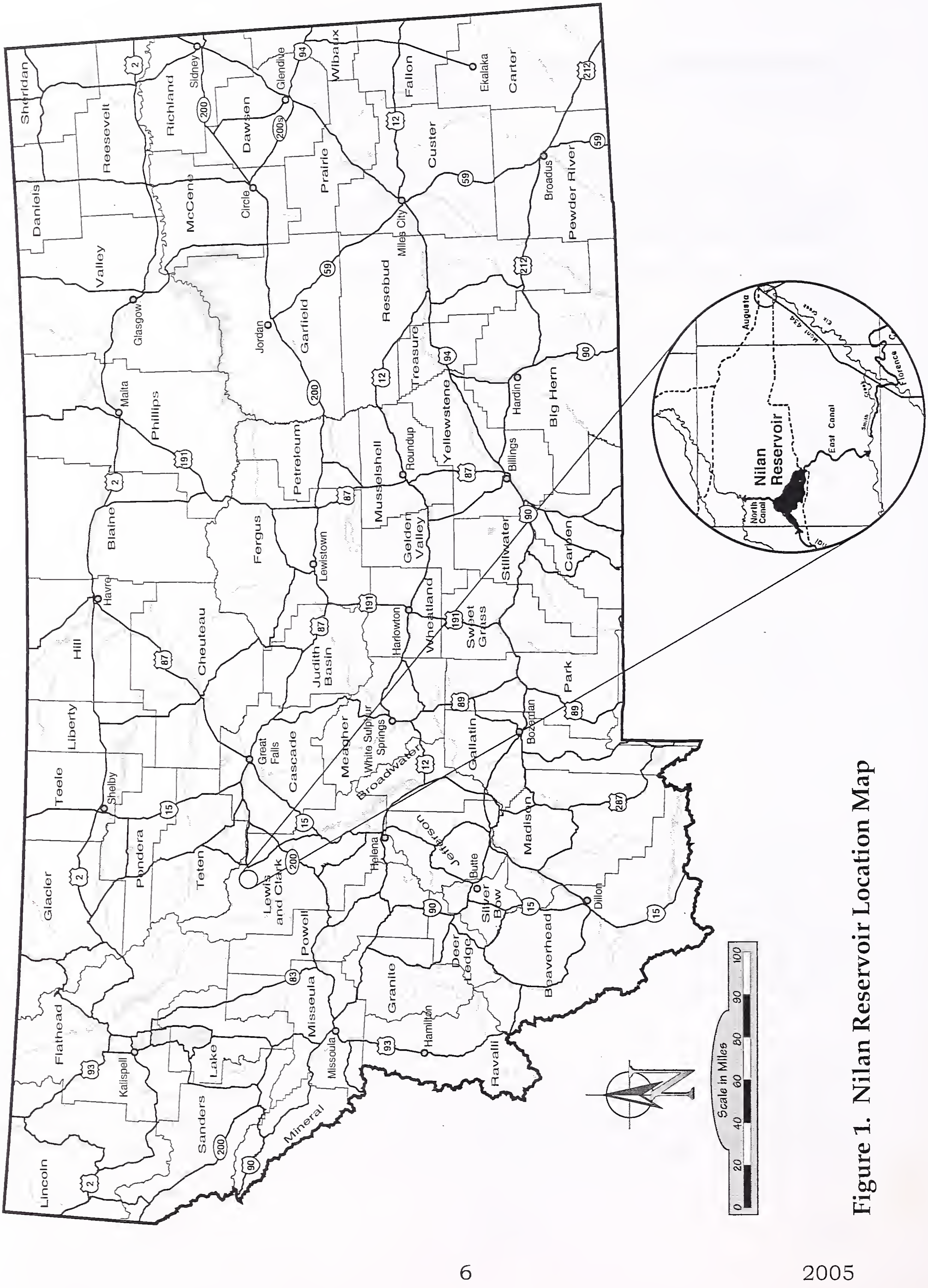


Figure 1. Nilan Reservoir Location Map

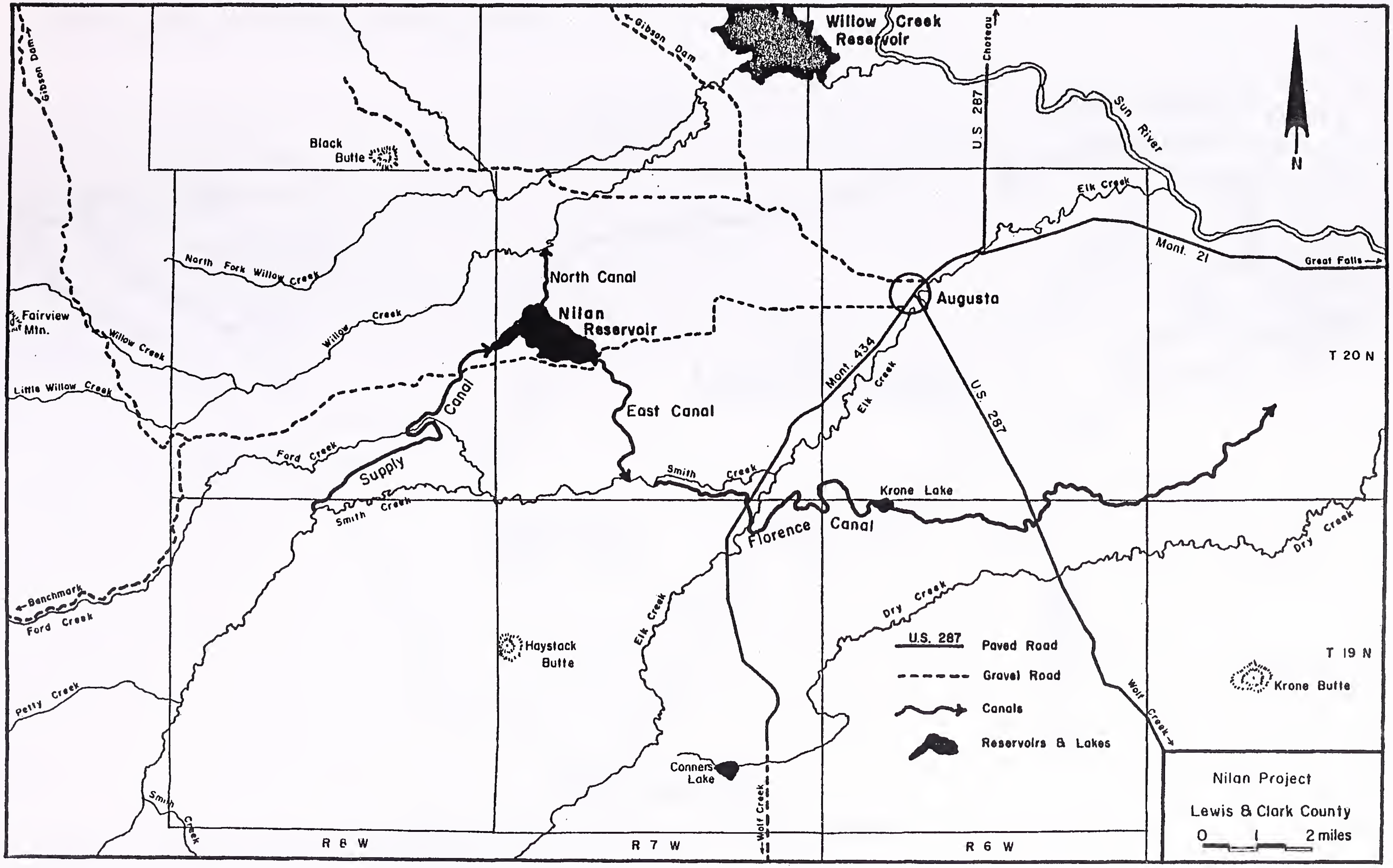


Figure 2. Nilan Reservoir Project Map

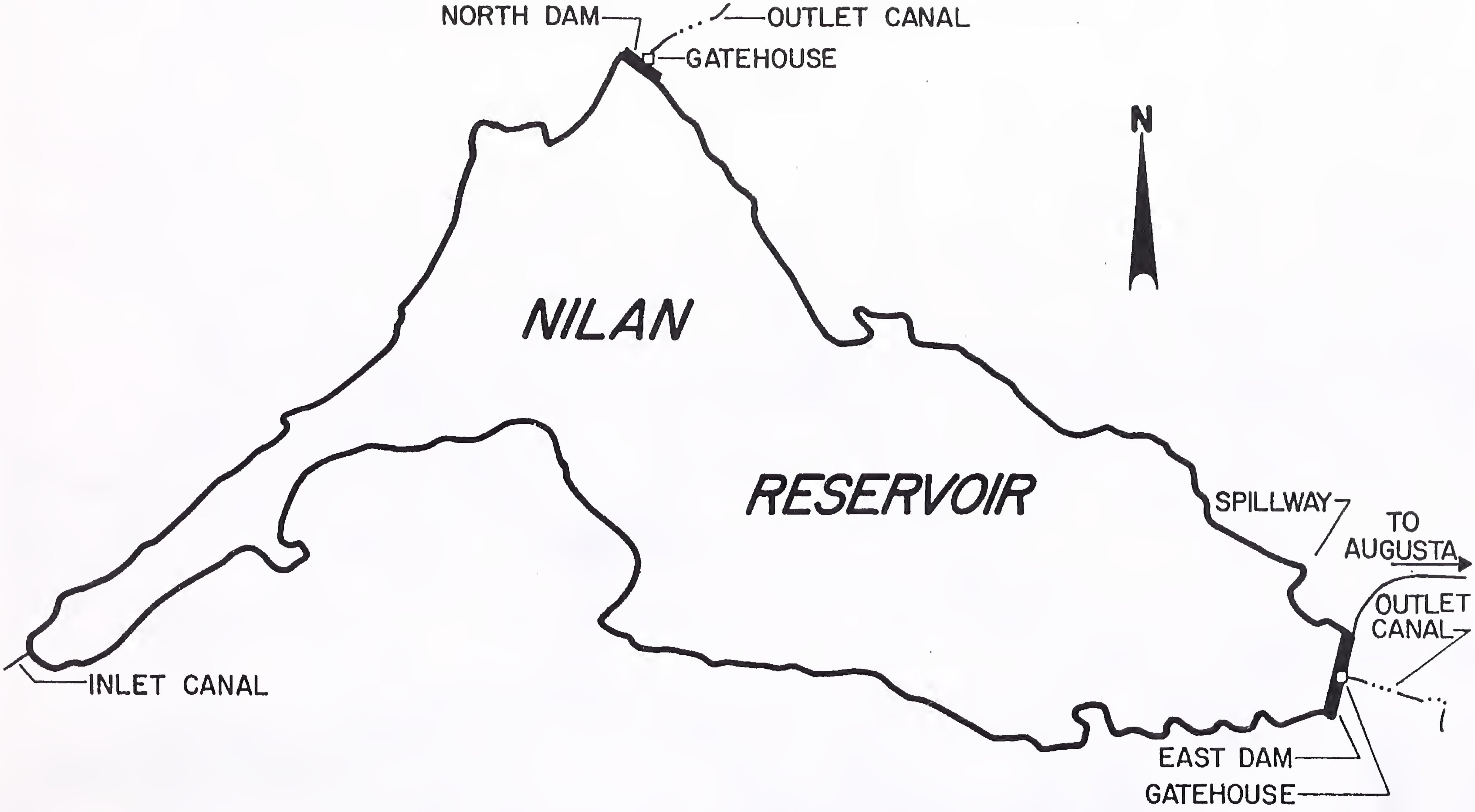


Figure 3. Nilan Reservoir General Layout

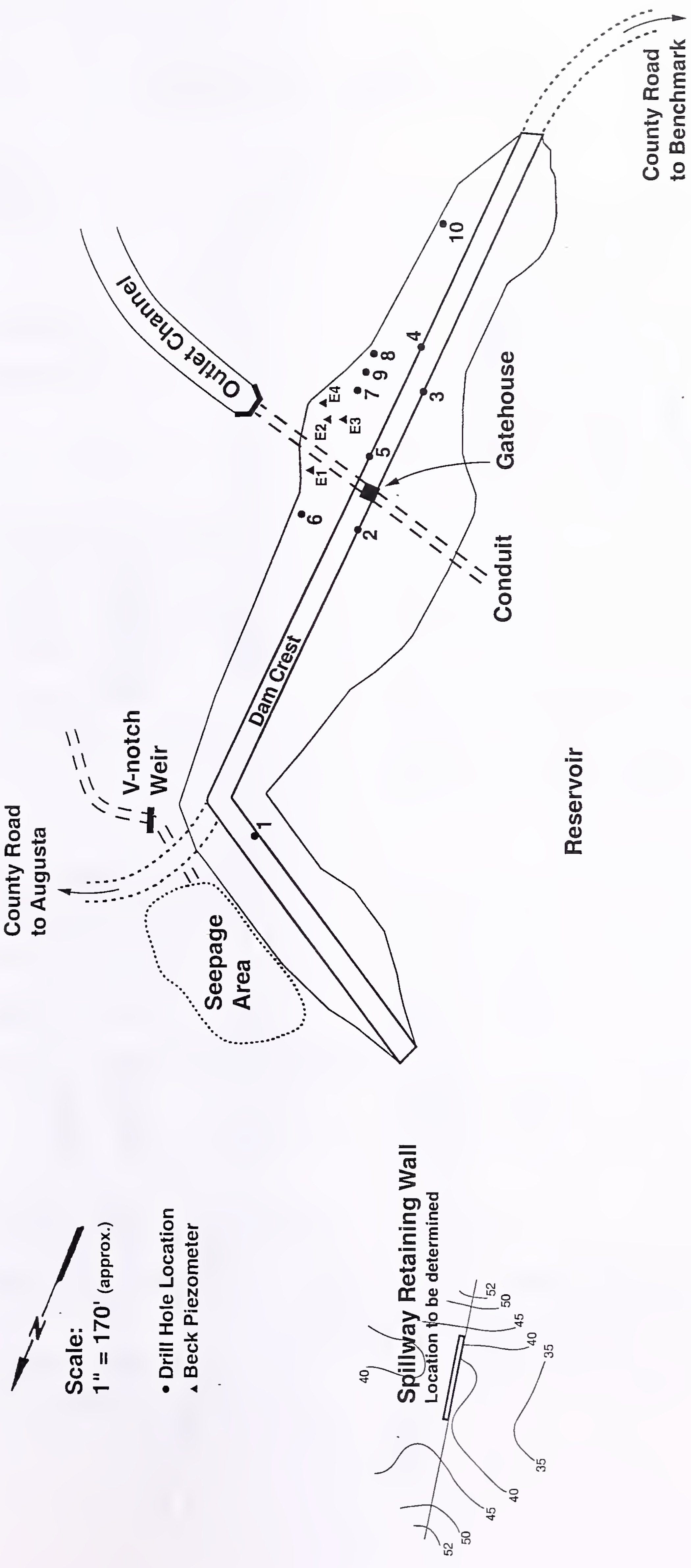


Figure 4. Nilan East Dam Monitoring Well Location

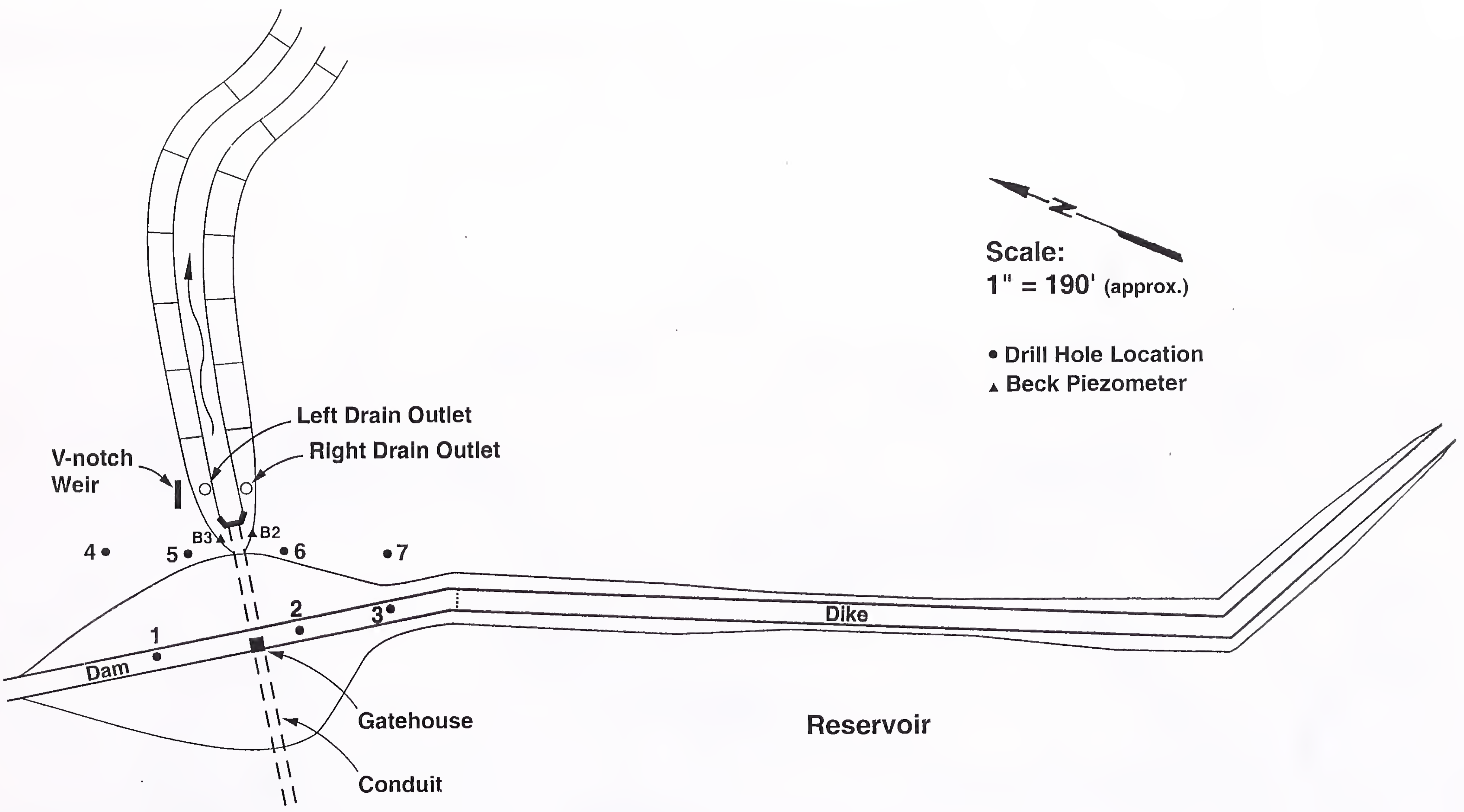


Figure 5. Nilan North Dam Monitoring Well Location

STATISTICAL INFORMATION

1. General

a. Owner	Montana Department of Natural Resources and Conservation (DNRC)
b. Operator	Nilan Water Users Association
c. Location	Sections 17, 18 (North Dam), 19 and 20 (East Dam), Township 20 North, Range 7 West
d. Latitude, East Dam	47° 28' 24"
Longitude, East Dam	112° 32' 18"
Latitude, North Dam	47° 29" 12"
Longitude, North Dam	112° 32' 18"
e. County/State	Lewis and Clark/Montana
f. Watershed Location	Between Willow Creek and Elk Creek, Sun River Basin.

2. Principle Elevations

a. Minimum Dam Crest	4,452.0 feet
b. Normal Full Pool	4,442.5 feet
c. Spillway Crest	4,442.5 feet
d. Outlet Conduit Invert (design)	
East Dam	4,400.75 feet
North Dam	4,397.25 feet

3. Reservoir

a. Length of Maximum Pool	0.78 miles
b. Maximum Reservoir Level of Record	4,442.9 feet (7/15/78)
c. Surface Area (at normal full pool)	525 acres

4. Storage

a. Maximum Storage (pool at dam crest)	15,600 acre-feet
b. Active Storage (pool at spillway crest)	10,092 acre-feet
c. Maximum Surcharge (from spillway to dam crest)	5,508 are-feet

5. Hydrology

a. Inflow Design Flood	½ Probable Maximum Flood (½ PMF) (12,400 cfs peak flow)
b. 100-Year Flood	421 cfs
c. 500-Year Flood	839 cfs

6. Embankment (East Dam)

a. Type	Earthfill
b. Hydraulic Height	51 feet
c. Crest Length	1,010 feet
d. Crest Width	20 feet
e. Upstream Slope	1v on 2h and 1v on 1.8h
f. Downstream Slope	1v on 2h

7. Embankment (North Dam)

a. Type	Earthfill
b. Hydraulic Height	54 feet
c. Crest Length	530 feet
d. Crest Width	20 feet
e. Downstream Slope	1v on 2.0h
f. Upstream Slope	1v on 2.0h

8. Embankment (North Dike)

a. Type	Earthfill
b. Hydraulic Height	8 feet
c. Crest Length	1,300 feet
d. Crest Width	20 feet
e. Downstream Slope	1v on 2.0h
f. Upstream Slope	1v on 2.0h

9. Outlet Works (East Dam)

a. Size	4-foot diameter, cast-in-place concrete conduit
b. Length	250 feet
c. Control	Double-chambered wet well located on the upstream edge of the dam crest with a 48-inch diameter operating sluice gate and a 48-inch by 48-inch square emergency slide gate.
d. Capacity at Dam Crest (pool at dam crest)	385 cfs
e. Trashrack	Yes

10. Outlet Works (North Dam)

a. Size	4-foot diameter, cast in place concrete conduit
b. Length	262 feet
c. Control	Double-chambered wet well located on the upstream edge of the dam crest with a 48-inch diameter operating sluice gate and a 48-inch by 48-inch square emergency sluice gate
d. Capacity at Dam Crest (pool at dam crest)	395 cfs
e. Trashrack	Yes

11. Spillway

a. Type	Unlined channel with concrete control weir
b. Crest Width	72 feet
c. Weir Size	1.8 feet high x 0.75 feet wide
d. Capacity (pool at dam crest)	8,620 cfs

OPERATING PROCEDURES

The association operates the Nilan Dams and reservoir to provide an adequate supply of irrigation water to meet contracts with the water users without exceeding safe storage and flow levels.

DAM OPERATOR

The responsibility for the daily operation of the canals, dams, and reservoir rests with the association and the dam operator. The dam operator is generally authorized to operate the reservoir to meet the association's goal of providing an adequate supply of irrigation water to met contracts with water users without exceeding safe storage and flow levels. The dam operator's specific responsibilities are to:

1. Operate the mechanical features of the outlet works.
2. Coordinate filling the reservoir and releasing the water.
3. Notifying the SWPB of any unusual occurrences such as impending floods, excessive seepage, and if the spillway is flowing.
4. Perform various maintenance tasks.
5. Maintain water level records and report findings to the SWPB.
6. Monitor weather conditions.
7. Monitor seepage.

Typically, the out-going dam operator, the association, and the SWPB train a new dam operator. The dam operator's training focuses on the mechanical operation of the gates, measurement of the storage level, measurement of the rate of water release, and record keeping.

The dam operator is normally available daily to observe the dams and perform operating functions during the filling and irrigation seasons, and is available at other times of the year. Communication among the dam operator, the association, and the SWPB usually takes place by telephone.

Although radio communications are not routinely available, during emergencies or unusual occurrences, radio communications may be established so the dam operator can speak directly with county authorities and with the SWPB **(see Nilan Reservoir East Dam and North Dam Emergency Plan)**.

METHOD AND SCHEDULE OF OPERATION

The association's goal is to have the reservoir full before contract holder's start calling for water. For the past several years, the supply canal has rarely been turned off. The supply canal is operated during winter as long as icing is not a problem. Even when icing does occur, some water continues to run through the canal under the ice.

The date irrigation releases begin varies from year to year, with May 1 the earliest that releases can begin. During typical years, releases begin around June 1 and end by September 30 as specified in the water purchase contracts. All dates tend to vary depending on each year's climatological and hydrological conditions.

Maximum Winter Storage: The maximum reservoir elevation for winter storage is 4,437.0 feet with 7,407 acre-feet of storage. This winter maximum helps prevent damage to the riprap and embankment from wind-driven waves and ice.

Minimum Winter Storage: The minimum reservoir elevation for winter storage is 4,409.0 feet with 525 acre-feet of storage. This winter minimum helps prevent ice damage to the inlet structure for the outlet works, minimizes water quality problems, and helps to maintain the fishery.

SAFE DRAWDOWN

Because neither of the Nilan Dams has been thoroughly investigated relative their structural stability, the DNRC recommends that drawdown rates not exceed one foot per day.

GATE OPERATION

The outlet works are used for controlling the release of irrigation water and not for providing emergency relief. If the outlet works are operated for emergency relief beyond the capacity of the outlet canals, the canals and the structures below the dam would be damaged.

The outlet gates are operated manually with a hand crank. The maximum the gates can be opened is 4 feet. Openings in excess of this amount may damage the gates, gate frames, gate stems or the gate operating pedestals. The 4 feet of operation is measured on the exposed portion of the gate stem between the top of the pedestal stem and the bottom of the stop nut.

At the maximum dam crest elevation, the combined outlet works capacity is 780 cfs. The maximum combined capacity of the delivery canals is 149 cfs. If the outlet works are operated far in excess of the delivery canals' capacity, the canals and canal structures can be damaged. Outlet rating tables are shown in Appendix A.

SPILLWAY

The spillway has a discharge of 8,620 cfs with the pool at the dam crest elevation. A rating table for the spillway is shown in Appendix A.

STORAGE DETERMINATION

Storage in the reservoir and the elevation of the reservoir surface are determined by taking a slope measurement. Measure in feet from the steel post, located in a concrete pad on the reservoir side of the parking lot on the south side of the East Dam, to the water surface. The elevation of the reservoir surface and the storage can then be found using the Slope-Elevation-Storage Table (Table 1) in Appendix A.

When the reservoir is at or below 3,271 acre-feet, the alternate slope line must be used. The 0+00 pin is located 92.6 feet from the southeast corner of the gatehouse, and over the outlet tunnel.

If water is not being diverted, storage and reservoir surface elevation can be determined by measuring from the top of the grill in the gatehouse to the water surface. The top of grill elevation is 4,452.0 feet. Subtract the vertical distance from the grill to the water surface from 4,452.0 to find the elevation of the water surface. Once the reservoir surface elevation is determined, the reservoir storage is found using the Elevation/Storage Table (Table 2) in Appendix A.

WEATHER MONITORING

The dam operator monitors weather conditions through local weather forecasts and the National Weather Service.

If severe flooding is anticipated, the NWS Great Falls Office (406-453-2081 or 406-453-4561) should be contacted for information about the storm, such as the estimated storm intensity and duration, runoff duration (above base flow), and total flood volume of the storm in the Willow Creek and Elk Creek drainages.

INTERACTION WITH OTHER DAMS

Willow Creek Dam and Reservoir is approximately 6 miles downstream from the Nilan North Dam. Greenfields Irrigation District operates Willow Creek Dam. The safety of Willow Creek Dam is not affected by the North Dam during normal operations

The town of Augusta is approximately 9 miles downstream from the Nilan East Dam. The safety of the town of Augusta is not affected by the by either of the East or North Dams during normal operation.

There are no dams below the Nilan East Dam and no dams upstream of Nilan Reservoir.

EMERGENCY

If it appears that either one or both of the Nilan Dams is about to breach, or during emergency operations, the dam operator will initiate the **Nilan Reservoir East Dam and North Dam Emergency Action Plan**.

The Town of Augusta is likely to begin flooding approximately 1.8 hours after a breach of the Nilan East Dam and approximately 3.9 hours after the failure of the North Dam. Therefore, if it appears that either dam will breach, the dam operator will initiate the Emergency Alert System which is described on page 21 of the **Nilan Reservoir East Dam and North Dam Emergency Action Plan.**

If the North Dam breaches, at least 10,000 cfs would be routed through Willow Creek Dam. Under such an emergency, the safety of Willow Creek Dam could be jeopardized. Therefore, if it appears the North Dam will breach, the dam operator should immediately notify Bob Hardin, manager of the Greenfields Irrigation District (**office: 406-467-2533, home 406-467-2308**).

INSPECTION AND MONITORING

The SWPB inspects the dams annually. Appendix B includes an example of a SWPB inspection report form. In addition to annual inspections, SWPB personnel will inspect the dams and reservoir during and after heavy runoff, severe rainstorms, and severe windstorms; during high storage periods; and after an earthquake. Both dams have monitoring wells and weirs.

STRUCTURAL FEATURES INSPECTION

Structural features include the gatehouses, spillway, and outlet works. The SWPB will inspect these structures annually as part of its inspection program. Items checked or noted include, but are not limited to:

1. Outlet Works
    a. Any differential settlement or movement resulting in cracking of the conduits.
    b. Erosion of the seals or the conduits by cavitation immediately downstream of the gates
    c. Major seepage of water into the conduits.
    d. Major deterioration of exposed concrete due to freeze/thaw cycles or sulfate reactions.
    e. Operation of the gates through a full cycle.
    f. Corrosion of any metal.
    g. Lubrication and cleaning of the pedestals.
    h. Air vents for unobstructed flow.
2. Gatehouses -- Any damage or vandalism.
3. Spillway
    a. Erosion of the spillway channel.
    b. Blockage of the approach.

   c. Deterioration of concrete.

4. Toe Area Upstream of Both Dams
   Inspect for the development of sinkholes when the area is exposed.

RIPRAP INSPECTION

The riprap along the face of each dam should be at least 30 inches thick. Immediately after the occurrence of high water, the riprap will be inspected and additional riprap added if needed.

DRAINS

East Dam: There are no known internal drains at the East Dam.

North Dam: There are two toe drainpipes that exit into each side of the outlet channel, approximately 25 feet downstream of the outlet.

INSTRUMENTATION

At the East Dam, seven monitoring wells were installed in the spring of 1999 -- five along the dam crest and two along the downstream toe. An additional monitoring well was installed along the downstream toe in the fall, 1999. Two more monitoring wells were added along the downstream toe in the fall of 2000. In addition, there are four shallow hand-driven "Beck" type piezometers at the toe of the dam around the outlet structure that were installed in 1997 and 1998.

At the North Dam, seven monitoring wells were installed in the fall of 1999 -- three along the dam crest and four along the downstream toe. Generally, two piezometers were installed in each monitoring well. In addition, there are four shallow hand-driven "Beck" type piezometers at the toe of the dam around the outlet structure that were installed in 1997.

Figures 4 and 5 show the general location of these monitoring wells. Soil profiles of the drill holes and details as to how the wells were constructed are shown in Appendix D.

SEEPAGE

Both dams at Nilan Reservoir show seepage. At the North Dam, the seepage is primarily in the toe area around the outlet channel headwalls. Swampy conditions exist throughout this area. The seepage is estimated at 1 to 2 gpm, but is not measurable. Above the left drain is another seep area that is monitored with a V-notch weir. This seep area is about 20 feet downstream from the outlet structure.

At the East Dam, seepage has been observed exiting along the right outlet wing wall, but is not measurable. Seepage also exits from the left abutment between the dam and the county road fill. The seepage flows under the county road through a 12-inch concrete pipe, and is measured with a v-notch weir on the downstream side of the county road. There is also a seepage area, approximately 70 feet in length, along the left side of the canal about 50 feet downstream the outlet structure, which is not measurable.

A V-notch weir discharge table is shown in Appendix A.

SEEPAGE MONITORING

The monitoring wells, seepage areas, drains and weirs at the dams are observed and monitored by the dam operator, DNRC

Helena Regional Office, and SWPB during regular visits; and may be measured by the SWPB during annual inspections.

The instruments are generally measured once per month in March, April, July, August, September, and October; and twice per month in May and June. Measurements may be taken during the winter months (November, December, January, February) depending on weather conditions. The monitoring data is maintained by the SWPB in Helena.

MAINTENANCE

The association is responsible for routine maintenance of the project. In addition, the SWPB may identify items that need maintenance or repair during the annual inspection.

ROUTINE MAINTENANCE

To protect the dam and keep it in good working order, the dam operator during regular visits to the dam will watch for and identify any potential maintenance requirements. As soon as a need is identified, the dam operator needs to schedule and perform the routine maintenance.

Items that may occasionally need attention include, but are not limited to:

1. *Lubrication of gate-operating mechanisms and keep the gate house and pedestals clean.*
2. *Debris or silt restricting the supply canals, spillway inlet or the outlet works.* Accumulated debris that could affect the operation of these appurtenances will be removed at once, with all debris removed at least annually.
3. *Erosion gullies on embankments.* Development of erosion gullies will be checked immediately. Gullies will be filled, compacted, and seeded. Particular attention will be paid to the abutment contact areas and the downstream faces where four-wheel drive tracks may become a problem.
4. *Rodent damage.* The rodents will be removed or destroyed, and any burrows holes should be filled immediately.
5. *Upstream slope riprap.* The upstream riprap of both dams and dike normally will be observed annually, but may occasionally need repairs because of high water or wave action.
6. *Vegetative cover on downstream slopes.* Good vegetative cover will be maintained, but large brush will be removed.

7. *Air vent.* The east dam has an air vent which sometimes gets covered inadvertently by the road maintenance crew. The air vent needs to be kept open.
8. *Noxious Weeds.* Noxious weeds on and around the dam embankments, dike, reservoir, and canals should be sprayed on at least as annual basis.
9. *Cleaning spillway and outlet structure wall tops.* The spillway and outlet structure wall tops should be clear of any dirt, rocks, grass, brush, and any overhanging vegetation or trees.
10. *Weirs.* These devices will be maintained clean of sediment and algae, kept upright, free flowing, and free of debris.

ANNUAL MAINTENANCE

The SWPB conducts annual inspections of the Nilan Dams and Reservoir. During these inspections, any items requiring annual maintenance will be identified and recorded. Items that may need annual maintenance include the spillway, outlet works, gates, riprap and gatehouses. Any other routine items that need immediate attention, such as removing trees or brush, will also be noted.

After the inspection the SWPB sends the association a Dam Safety Inspection Report and a Maintenance Schedule Report. The reports identify items that need maintenance and provides a schedule of when the maintenance tasks need to be completed. The association is responsible for performing the maintenance items within the times specified.

The dam operator or association members may perform the maintenance tasks. However, major repairs will likely be handled by a contractor. The SWPB may assist in contracting for repairs and may supervise the work.

RECORD KEEPING

The SWPB will maintain records, including photographs, of all inspections, and maintenance requirements. These records also include seepage monitoring observations. Anyone who wants to review these records may so in the SWPB's office at the Department of Natural Resources and Conservation in Helena, Montana.

The dam operator will keep records of the reservoir elevation, seepage observations or measurements, and any unusual conditions. These records may be reviewed at the dam operators house.

REFERENCES

U.S. Army Corps of Engineers. July 1981. Phase One Inspection Report, National Dam Safety Program, Elk Creek Basin, Nilan East Dam, MT-14, Willow Creek Basin, Nilan North Dam, MT-3206, Augusta, Montana. Prepared for the State of Montana (DNRC) by Morrison-Maierle, Inc. under the U.S. Army Corps of Engineers Nation Dam Safety Program.

Artz, Bert, Nilan Dam Operator: September 1993 and February 1994.

Personal telephone conversation and meeting with Marvin Cross, Havre Regional Office Civil Engineering Specialist, Water Resources Division, DNRC, Havre.

Parish, Lovell, Regional Geologist. 1998. Geotechnical Inspection of Nilan East and Nilan North Dam and Dike - Lewis and Clark County , Montana. Prepared for the State of Montana (DNRC) by the Bureau of Reclamation, Great Plains Office, Billings Regional Office, Montana.

APPENDICES

APPENDIX A

RATING CURVES AND TABLES

TABLE 1. SLOPE-ELEVATION-STORAGE TABLE
NILAN RESERVOIR

Pins installed and elevations established with a level on 10/3/2000.
The 0+00 pin is at the base of the steel post in the concrete pad which is on the reservoir side of the parking area just west of the right (southwest) end of the dam.
The alignment is slightly right of the previous line and terminates in a depression which will go dry to the north at 4426.88 ft of elevation and to the west at 4424.33 ft of elevation.
One pin was installed for an alternate slope below the gatehouse. See notes in table on page A4.
Storage volumes from the 7/1997 slope pin table.

DISTANCE	ELEVATION	STORAGE
0+00 IS THE BASE OF THE STEEL POST IN THE CONCRETE PAD	4451.20	15,112
1	4451.03	15,015
2	4450.85	14,907
3	4450.68	14,812
4	4450.51	14,716
5	4450.34	14,618
6	4450.16	14,515
7	4449.99	14,415
8	4449.82	14,319
9	4449.64	14,215
10	4449.47	14,117
11	4449.24	13,986
12	4449.02	13,859
13	4448.79	13,726
14	4448.56	13,594
15	4448.34	13,467
16	4448.11	13,336
17	4447.88	13,203
18	4447.65	13,071
19	4447.43	12,944
20	4447.20	12,812
21	4447.01	12,703
22	4446.82	12,594
23	4446.62	12,479
24	4446.43	12,370
25	4446.24	12,260
26	4446.05	12,151
27	4445.86	12,041
28	4445.66	11,926
29	4445.47	11,818
30	4445.28	11,708
31	4445.13	11,622
32	4444.98	11,536
33	4444.84	11,455
34	4444.69	11,369
35	4444.54	11,282
DISTANCE	ELEVATION	STORAGE

DISTANCE	ELEVATION	STORAGE
36	4444.39	11,197
37	4444.24	11,111
38	4444.10	11,030
39	4443.95	10,943
40	4443.80	10,857
41	4443.68	10,788
42	4443.55	10,713
43	4443.43	10,645
44	4443.31	10,576
45	4443.18	10,501
46	4443.06	10,432
47	4442.94	10,360
48	4442.81	10,281
49	4442.69	10,208
50	4442.57	10,135
0+50 CAP	4442.56	10,129
SPILLWAY	4442.50	10,092
51	4442.48	10,080
52	4442.39	10,025
53	4442.30	9,970
54	4442.21	9,915
55	4442.12	9,860
56	4442.04	9,811
57	4441.95	9,762
58	4441.86	9,716
59	4441.77	9,671
60	4441.68	9,625
61	4441.58	9,575
62	4441.48	9,524
63	4441.38	9,474
64	4441.27	9,418
65	4441.17	9,368
66	4441.07	9,317
67	4440.97	9,267
68	4440.87	9,218
69	4440.77	9,169
70	4440.67	9,120
DISTANCE	ELEVATION	STORAGE

TABLE 1. SLOPE-ELEVATION-STORAGE TABLE (continued)

NILAN RESERVOIR

DISTANCE	ELEVATION	STORAGE
71	4440.50	9,037
72	4440.33	8,954
73	4440.17	8,875
74	4440.00	8,792
75	4439.84	8,716
76	4439.67	8,635
77	4439.50	8,554
78	4439.34	8,464
79	4429.17	8,398
80	4439.00	8,317
81	4438.91	8,276
82	4438.81	8,230
83	4438.71	8,184
84	4438.62	8,142
85	4438.52	8,096
86	4438.42	8,050
87	4438.33	8,009
88	4438.23	7,963
89	4438.13	7,917
90	4438.04	7,875
91	4437.98	7,848
92	4437.92	7,821
93	4437.86	7,794
94	4437.80	7,767
95	4437.74	7,740
96	4437.68	7,713
97	4437.63	7,690
98	4437.57	7,664
99	4437.51	7,637
100	4437.45	7,610
1+00 CAP	4437.41	7,592
101	4437.41	7,592
102	4437.36	7,569
103	4437.32	7,551
104	4437.27	7,528
105	4436.89	7,359
106	4436.50	7,187
107	4436.11	7,015
108	4436.01	6,971
109	4435.92	6,933
110	4435.82	6,890
111	4435.66	6,822
112	4435.50	6,754
113	4435.34	6,686
114	4435.18	6,618
115	4435.02	6,550
116	4434.86	6,484
117	4434.70	6,417
118	4434.54	6,351
119	4434.38	6,285
120	4434.22	6,218
121	4434.06	6,152
122	4433.90	6,087
123	4433.74	6,025
124	4433.58	5,961
125	4433.42	5,898
126	4433.26	5,834
127	4433.10	5,771
128	4432.94	5,710
129	4432.78	5,648
130	4432.62	5,591
131	4432.41	5,514
132	4432.20	5,436
133	4432.00	5,362
134	4431.79	5,290
135	4431.58	5,217
136	4431.38	5,156
137	4431.17	5,075
138	4430.96	5,004
139	4430.76	4,941
140	4430.54	4,872
141	4430.33	4,806
142	4430.12	4,739
143	4429.91	4,675
144	4429.70	4,612
145	4429.48	4,546
146	4429.27	4,483
147	4429.06	4,420
148	4428.85	4,357
149	4428.64	4,294
150	4428.43	4,232
1+50 CAP	4428.28	4,187
151	4428.20	4,163
152	4427.98	4,097
153	4427.76	4,033
154	4427.54	3,970
155	4427.32	3,906
156	4427.10	3,842
157	4426.88	3,778
158	4426.66	3,714
DISTANCE	ELEVATION	STORAGE

2005

TABLE 1. SLOPE-ELEVATION-STORAGE TABLE (continued)

NILAN RESERVOIR

DISTANCE	ELEVATION	STORAGE
159	4426.44	3,651
160	4426.22	3,587
161	4426.13	3,561
162	4426.04	3,535
163	4425.95	3,509
164	4425.86	3,478
165	4425.77	3,459
166	4425.68	3,433
167	4425.58	3,405
168	4425.49	3,380
169	4425.40	3,355
170	4425.38	3,349
171	4425.35	3,341
172	4425.32	3,333
173	4425.29	3,324
174	4425.27	3,319
175	4425.24	3,310
176	4425.21	3,302
177	4425.18	3,293
178	4425.16	3,288
179	4425.13	3,279
180	4425.10	3,271
DISTANCE	ELEVATION	STORAGE

ALTERNATE SLOPE LINE BELOW GATE HOUSE

The A0+00 pin is 92.6 feet from the southeast corner of the gatehouse, and over the outlet tunnel.
There is 0.36 feet of vertical water surface drop that is not covered between the two tables

DISTANCE	ELEVATION	STORAGE
A0+00 CAP	4424.74	3,173
1	4424.44	3,092
2	4424.15	3,014
3	4423.86	2,938
4	4423.56	2,865
5	4423.27	2,794
6	4423.09	2,750
7	4422.90	2,705
8	4422.72	2,664
9	4422.53	2,620
10	4422.35	2,579
11	4422.13	2,528
12	4421.92	2,480
13	4421.71	2,434
14	4421.50	2,387
15	4421.29	2,341
16	4420.99	2,272
17	4420.69	2,212
18	4420.39	2,149
19	4420.09	2,086
20	4419.79	2,028
21	4419.35	1,945
22	4418.91	1,864
23	4418.47	1,785
24	4418.03	1,705
25	4417.59	1,630
26	4417.04	1,537
27	4416.49	1,448
28	4415.94	1,361
29	4415.39	1,278
30	4414.84	1,198
DISTANCE	ELEVATION	STORAGE

TABLE 2. ACTIVE STORAGE IN ACRE-FEET

NILAN RESERVOIR

ELEV	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4,401	0	3	6	9	12	15	18	21	24	27
4,402	30	34	39	43	48	52	57	61	66	70
4,403	75	80	86	91	97	102	108	113	119	124
4,404	130	136	143	149	156	162	168	175	181	188
4,405	194	201	207	214	220	227	234	240	247	253
4,406	260	268	276	284	292	300	308	616	324	332
4,407	340	349	358	367	376	385	394	403	412	421
4,408	430	439	449	458	468	477	487	496	506	515
4,409	525	534	544	554	563	573	583	592	602	611
4,410	621	631	641	651	661	670	680	690	700	710
4,411	720	731	742	753	764	775	786	797	808	819
4,412	830	842	854	866	878	890	902	914	926	938
4,413	950	963	976	989	1,002	1,015	1,028	1,041	1,054	1,067
4,414	1,080	1,094	1,108	1,122	1,136	1,150	1,164	1,178	1,192	1,206
4,415	1,220	1,235	1,250	1,265	1,280	1,295	1,310	1,325	1,340	1,355
4,416	1,370	1,386	1,402	1,418	1,434	1,450	1,466	1,482	1,498	1,514
4,417	1,530	1,547	1,564	1,581	1,598	1,615	1,632	1,649	1,666	1,683
4,418	1,700	1,718	1,736	1,754	1,772	1,790	1,808	1,826	1,844	1,862
4,419	1,880	1,899	1,917	1,936	1,955	1,973	1,992	2,011	2,030	2,048
4,420	2,067	2,088	2,109	2,130	2,151	2,172	2,193	2,214	2,235	2,256
4,421	2,277	2,299	2,321	2,343	2,365	2,387	2,410	2,432	2,454	2,476
4,422	2,498	2,521	2,544	2,567	2,590	2,613	2,636	2,659	2,682	2,705
4,423	2,728	2,752	2,777	2,801	2,825	2,850	2,875	2,899	2,924	2,948
4,424	2,973	3,000	3,027	3,054	3,081	3,108	3,135	3,162	3,189	3,216
4,425	3,243	3,271	3,299	3,327	3,355	3,383	3,411	3,439	3,467	3,495
4,426	3,523	3,552	3,581	3,610	3,639	3,668	3,697	3,726	3,755	3,784
4,427	3,813	3,842	3,871	3,900	3,929	3,958	3,987	4,016	4,045	4,074
4,428	4,103	4,132	4,163	4,193	4,223	4,252	4,282	4,312	4,342	4,372
4,429	4,402	4,432	4,462	4,492	4,522	4,552	4,582	4,612	4,642	4,672
4,430	4,702	4,733	4,765	4,796	4,828	4,859	4,891	4,922	4,954	4,985
4,431	5,017	5,051	5,086	5,120	5,155	5,189	5,224	5,258	5,293	5,327
4,432	5,362	5,399	5,436	5,473	5,510	5,547	5,584	5,621	5,658	5,695
4,433	5,732	5,771	5,811	5,850	5,890	5,929	5,969	6,008	6,048	6,087
4,434	6,127	6,168	6,210	6,251	6,293	6,334	6,376	6,417	6,459	6,500
4,435	6,542	6,584	6,627	6,669	6,712	6,754	6,797	6,839	6,882	6,924
4,436	6,967	7,011	7,055	7,099	7,143	7,187	7,231	7,275	7,319	7,363
4,437	7,407	7,452	7,497	7,542	7,587	7,632	7,677	7,722	7,767	7,812
4,438	7,857	7,903	7,949	7,995	8,041	8,087	8,133	8,179	8,225	8,271
4,439	8,317	8,364	8,412	8,459	8,507	8,554	8,602	8,649	8,697	8,744
4,440	8,792	8,841	8,890	8,939	8,988	9,037	9,086	9,135	9,184	9,233
4,441	9,282	9,332	9,383	9,433	9,484	9,534	9,585	9,635	9,686	9,736
4,442	9,787	9,848	9,909	9,970	10,031	10,092	10,153	10,214	10,275	10,366

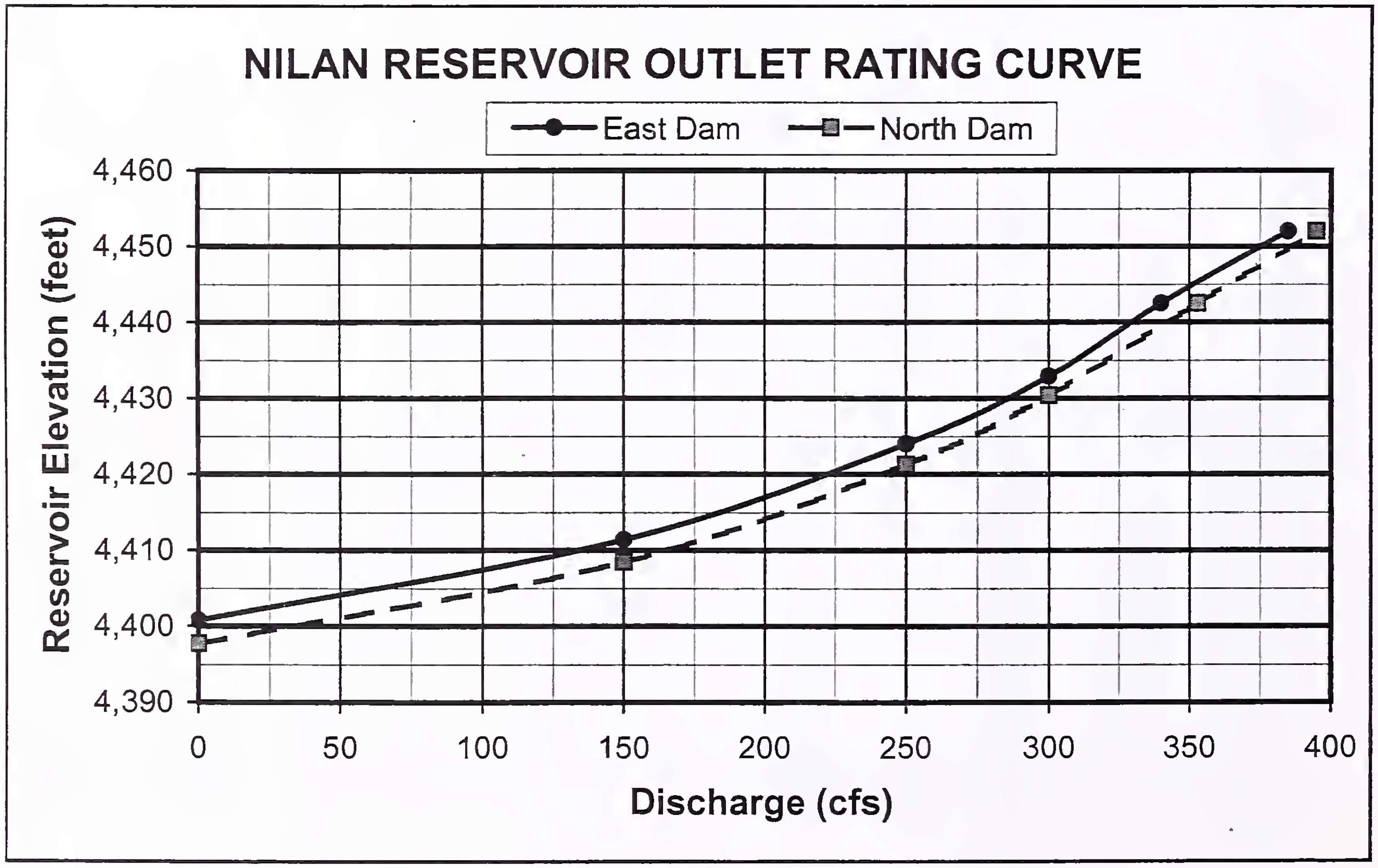
NOTE: Storage table based on 1938 original hand surveys of the reservoir.

Spillway Crest Elevation	4,442.5 feet
Top of Grill in Gatehouse	4,452.0 feet
Top of Dam Crest	4,452.0 feet

TABLE 3. OUTLET DISCHARGE

NILAN RESERVOIR

East Dam			North Dam	
Reservoir Elevation (feet)	Discharge (cfs)		Reservoir Elevation (feet)	Discharge (cfs)
4,400.75	0		4,397.75	0
4,411.40	150		4,408.50	150
4,424.00	250		4,421.30	250
4,432.90	300		4,430.40	300
4,442.50	340	Spillway Crest	4,442.50	353
4,452.00	385	Dam Crest	4,452.00	395

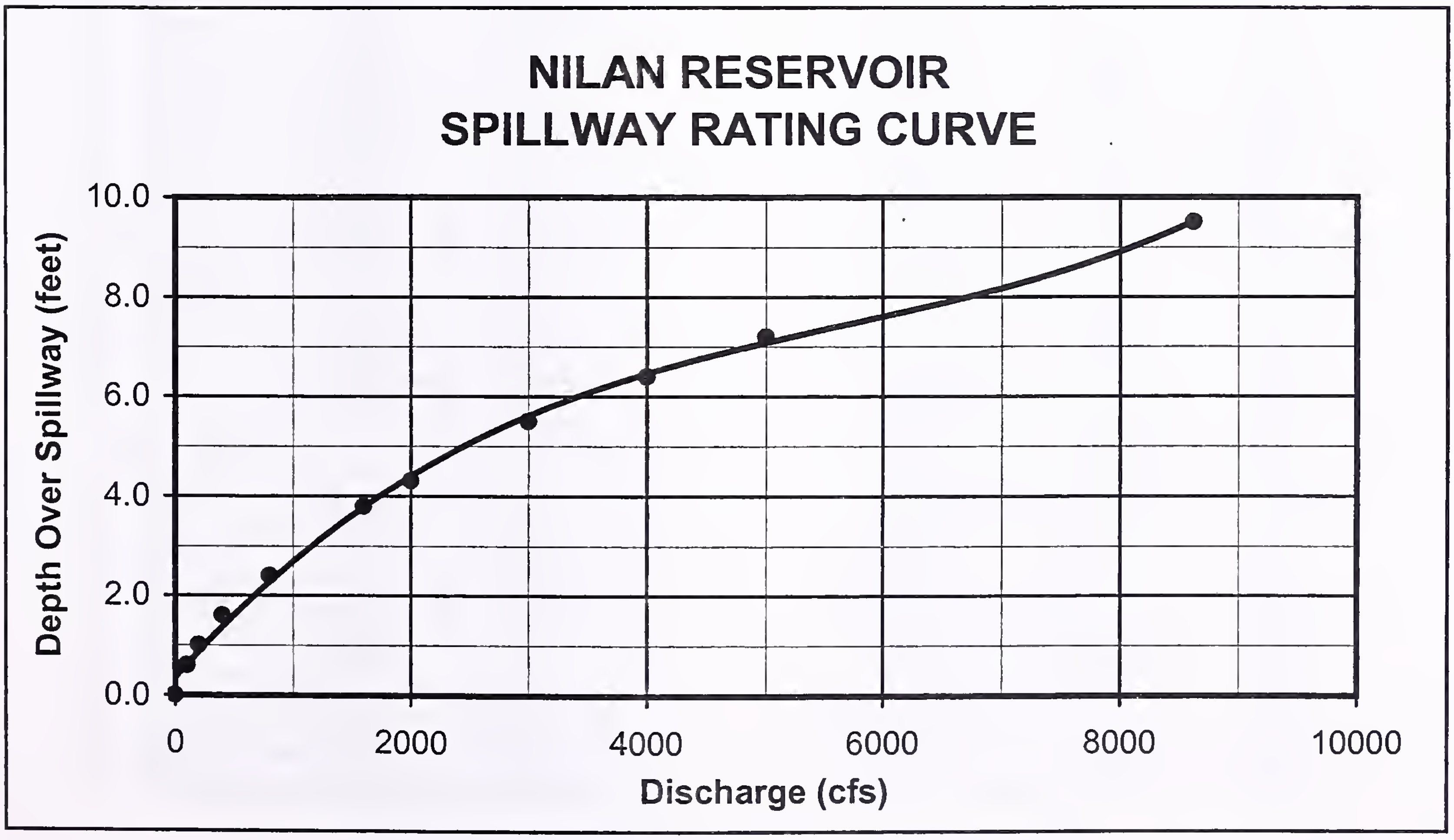


Notes: Discharge assumes operating gate is completely open.
Data from the Corps of Engineers Phase 1 Inspection Report (1981).

TABLE 4. SPILLWAY DISCHARGE

NILAN RESERVOIR

Depth Over Crest (feet)	Elevation (feet)	Discharge (cfs)
0.0	4,442.5	0
0.6	4,443.1	100
1.0	4,443.5	200
1.6	4,444.1	400
2.4	4,444.9	800
3.8	4,446.3	1,600
4.3	4,446.8	2,000
5.5	4,448.0	3,000
6.4	4,448.9	4,000
7.2	4,449.7	5,000
9.5	4,452.0	8,620



Note: Data from the Corps of Engineers Phase 1 Inspection Report (1981).

TABLE 5. V-NOTCH WEIR RATING TABLE

HEAD	DISCHARGE		HEAD	DISCHARGE	
(IN)	(GPM)	(CFS)	(IN)	(GPM)	(CFS)
---------	---------	---------	4.1	77.8	0.173
---------	---------	---------	4.2	82.6	0.184
---------	---------	---------	4.3	87.5	0.195
---------	---------	---------	4.4	92.6	0.206
0.5	0.4	0.001	4.5	98.0	0.218
0.6	0.7	0.001	4.6	103.4	0.230
0.7	1.0	0.002	4.7	109.1	0.243
0.8	1.4	0.003	4.8	115.0	0.256
0.9	1.8	0.004	4.9	121.0	0.270
1.0	2.4	0.005	5.0	127.2	0.283
1.1	3.0	0.007	5.1	133.6	0.298
1.2	3.7	0.008	5.2	140.2	0.312
1.3	4.5	0.010	5.3	147.0	0.328
1.4	5.4	0.012	5.4	154.0	0.343
1.5	6.4	0.014	5.5	161.2	0.359
1.6	7.5	0.017	5.6	168.5	0.375
1.7	8.8	0.020	5.7	176.1	0.392
1.8	10.1	0.022	5.8	183.8	0.410
1.9	11.5	0.026	5.9	191.8	0.427
2.0	13.1	0.029	6.0	199.9	0.445
2.1	14.8	0.033	6.1	208.3	0.464
2.2	16.6	0.037	6.2	216.9	0.483
2.3	18.5	0.041	6.3	225.6	0.503
2.4	20.6	0.046	6.4	234.6	0.523
2.5	22.8	0.051	6.5	243.8	0.543
2.6	25.1	0.056	6.6	253.2	0.564
2.7	27.6	0.061	6.7	262.9	0.586
2.8	30.2	0.067	6.8	272.7	0.608
2.9	32.9	0.073	6.9	282.8	0.630
3.0	35.8	0.080	7.0	293.0	0.653
3.1	38.9	0.087	7.1	303.5	0.676
3.2	42.1	0.094	7.2	314.2	0.700
3.3	45.4	0.101	7.3	325.2	0.725
3.4	48.9	0.109	7.4	336.3	0.749
3.5	52.5	0.117	7.5	347.7	0.775
3.6	56.3	0.126	7.6	359.3	0.801
3.7	60.3	0.134	7.7	371.2	0.827
3.8	64.4	0.144	7.8	383.2	0.854
3.9	68.7	0.153	7.9	395.5	0.881
4.0	73.1	0.163	8.0	408.1	0.909

$Q = (2.49\,(H/12)^{2.48})(448.83)$

Q in gpm

H in inches

APPENDIX B.

INSPECTION REPORT FORM

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
DAM SAFETY INSPECTION REPORT

NAME OF DAM
DATE INSPECTED

INVENTORY NO. ______________
HAZARD CATEGORY __________
TYPE OF DAM ________________
YEAR BUILT _________________

OWNER _________________________
OPERATOR _____________________
STREAM ________________________
DRAINAGE AREA ________________

Reservoir Storage Status

	Water Surface Elevation (feet)	Storage (acre-feet)
At time of inspection	________	________
At spillway crest	________	________
At min. dam crest elevation	________	________

ITEM	YES	NO	REMARKS

1. EMBANKMENT

A. Crest -- Height= Length= Width=

(1) Any visual settlements?			
(2) Any misalignments?			
(3) Any cracking?			
(4) Any traffic damage?			
(5) Other?			

ITEM	YES	NO	REMARKS

1. EMBANKMENT (continued)

B. Upstream Face -- Slope=

(1) Any erosion?			
(2) Any longitudinal cracks?			
(3) Any transverse cracks?			
(4) Is riprap protection adequate?			
(5) Any stone deterioration?			
(6) Any visual settlement, slumps, sloughing, depressions or bulges?			
(7) Adequate grass cover?			
(8) Debris on the dam face?			
(9) Other?			

C. Downstream Face--Slope=

(1) Any erosion?			
(2) Any longitudinal cracks?			
(3) Any transverse cracks?			
(4) Any visual settlement, slumps, sloughing, depressions or bulges?			
(5) Is the toe drain dry?			
(6) Are the relief wells flowing?			
(7) Any boils at the toe?			
(8) Any seepage areas?			
(9) Any traffic or animal damage?			
(10) Any burrowing animals?			
(11) Adequate grass cover?			
(12) Other?			

D. Amount and Type of Vegetation on the Dam

ITEM	YES	NO	REMARKS

2. ABUTMENT CONTACTS

A) Any erosion?			
B) Any visual differential movement?			
C) Any cracks?			
D) Any seepage present?			
E) Other?			

3. OUTLET WORKS

A. Intake Structure -- Size=

(1) Any settlement?			
(2) Any tilting?			
(3) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(4) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(5) Metal appurtenances:			
a. Any corrosion present?			
b. Any breakage present?			
(6) Trash rack?			
a. Condition?			
b. Anchor system secure?			
(7) Other?			

ITEM	YES	NO	REMARKS

3. OUTLET WORKS (continued)

B. Conduit -- Type = Size =

(1) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(2) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(3) Is the conduit metal?			
a. Any corrosion present?			
b. Protective coatings adequate?			
(4) Is the conduit misaligned?			
(5) Any calcium deposits?			
(6) Other?			

C. Gates and Tower

(1) Gates:			
a. Size: Operating: Emergency: b. Type: Operating: Emergency:			
(2) Controls operational?			
(3) Controls lubricated?			
(4) Operational problems?			
(5) Leakage around gates?			
(6) Condition of gate seals?			
(7) Any cavitation damage? If so, describe?			
(8) Describe air vent-size and condition.			

ITEM	YES	NO	REMARKS

3. OUTLET WORKS (continued)

C. Gates and Tower (continued)

(9) Is there a jet pump?			
a. Is it operational?			
b. Leakage?			
(10) Is the tower dry? _____ wet?			
(11) Any seepage in the tower?			
(12) Condition of the tower?			
(13) Any safety problems?			
(14) Ladder in good condition?			
(15) Condition of the gatehouse?			
(16) Emergency plan completed for the dam?			
a. Posted in the gatehouse?			
(17) Other?			

D. Stilling Basin

(1) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(2) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(3) Do energy dissipaters show:			
a. Signs of deterioration?			
b. Are they covered with debris?			
(4) Other?			

ITEM	YES	NO	REMARKS

3. OUTLET WORKS (continued)

E. Downstream Channel

(1) Is the channel:			
a. Eroding or backcutting?			
b. Sloughing?			
c. Obstructed?			
(2) Is released water:			
a. Undercutting the outlet?			
b. Eroding the embankment?			
(3) Other?			

4. SPILLWAY

A. Description

(1) Location?			
(2) Type of Spillway?			
(3) Size of Spillway?			
(4) Spillway lining?			
(5) Is there a weir?			
(6) Is the spillway in good condition?			
(7) Any drains?			
a. Describe the condition of drains.			

B. Does spillway show:

(1) Any cracking concrete?			
(2) Any spalling concrete?			
(3) Any exposed reinforcement in the concrete?			
(4) Any erosion?			

ITEM	YES	NO	REMARKS

4. SPILLWAY (continued)

4. B. Does spillway show: (continued)

(5) Any slope sloughing?			
(6) Any obstructions?			
(7) Displacement or offset joints?			
(8) Loss of joint material?			
(9) Leakage at the joints?			
(10) Other?			

C. Do the energy dissipaters show:

(1) Signs of deterioration?			
(2) Any cracking?			
(3) Any spalling?			
(4) Any exposed reinforcement?			
(5) Are they covered with debris?			
(6) Other?			

D. Has release water:

(1) Eroded the embankment?			
(2) Undercut the outlet?			
(3) Eroded the downstream channel?			
(4) Other?			

E. Emergency Spillway

(1) Is there an emergency spillway?			(If YES, describe)

ITEM	YES	NO	REMARKS

5. RESERVOIR CONTROL

A) Recent upstream development?			
B) Recent downstream development?			
C) Slides in reservoir area?			
D) Change in reservoir operation?			
E) Large impoundment upstream?			
F) Any debris in the reservoir?			
G) Other?			

6. INSTRUMENTATION

A) List type(s) of instrumentation:			
B) In good condition?			
C) Read periodically?			
D) Is data available?			
E) Include all data gathered since last report.			

7. DOWNSTREAM CONDITION

A. Downstream Land Use.

This dam was inspected by:

Additional comments and recommendations.

APPENDIX C

DISTRIBUTION LIST

NILAN RESERVOIR DAMS O&M DISTRIBUTION LIST

	Number Of Copies
1. State Water Projects Bureau	6
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6. Dam Operator	3
Dam Operator (Shorty Henry)	
Gate Houses (2)	
7. State Library -- Attn: Roberta Gebhardt	4
8. Extra	2
TOTAL	21

APPENDIX D

MONITORING WELL LOGS

SOIL LOG OF BOREHOLE NO: DH1B

(Page 1 of 2)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan East Dam
DATE STARTED : 4/15/1999
DATE COMPLETED : 4/15/1999
DRILL COMPANY : O'Keefe Driling
DRILLER :
DRILL RIG : MB61
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Ed Snyder (ESA)
APPROVED BY : Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4452.8	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	4452		0 to 16' CLAY, some fine sand, brown, very stiff, moist, slightly calcareous									
5	4447	☒				SS	8 12 13	39	18/18	100%		SPT #1 3.9 to 5.4'
				CL								
10	4442	☒	9 to 10.5' some gravel, yellow brown to gray brown, very moist			SS	16 19 19	39	18/18	100%		SPT #2 9 to 10.5'
15	4437	☒	14 to 15' yellow brown to rusty brown, gravelly, sandy 15' gray with black streaks			SS	7 9 14	21	18/18	100%		SPT #3 14 to 15.5'
		☒	16 to 37' SANDY CLAY, gravelly, mixed gray and brown with iron stain streaks, very stiff			ST			0/30	0%		ST #4 16 to 18.5' 3" Shelby Tube - hit rock, collapsed tube, bagged sample
		☒				ST			8/30	0%		ST #5 19 to 19.7' 3" Shelby Tube - rock collapsed tube
20	4432	☒		CL		SS	17 20 16	28	18/18	100%		SPT #6 20 to 21.5'
25												

DH1A was drilled right next to DH1B. No field log was prepared for DH1A.

08-29-2005 G:\WATER_PR\PROJECTS\Bob A\Well Logs\Nilan East Dam\Nilan East DH-1B Soil.bor

SOIL LOG OF BOREHOLE NO: DH1B

(Page 2 of 2)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/15/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/15/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Driling	LOGGED BY	: Ed Snyder (ESA)
DRILLER	:	APPROVED BY	: Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4452.8	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
25	4427	☒	25.2 to 25.5' silty fine sand, gray, moist		▨	SS	8 6 11	13	18/18	100%		SPT #7 24 to 25.5'
			28 to 37' yellow brown with iron staining, very stiff, very moist	CL	▨							
30	4422	☒				SS	15 13 30	31	18/18	100%		SPT #8 29 to 30.5'
35	4417	☒				SS	12 17 17	24	18/18	100%		SPT #9 34 to 35.5'
			37 to 43' CLAYEY GRAVEL, sandy, brown to gray brown, medium dense, very moist to wet	GC	▨							
40	4412	☒				SS	11 13 14	18	6/18	33%		SPT #10 39 to 40.5'
			43 to 44.5' SAND, medium dense, wet	SW	░							
			44.5 to 48.8' SANDY CLAY, gravelly, stiff, brown, very moist to wet	CL	▨							
45	4407	☒				SS	21 13 16	18	18/18	100%		SPT #11 44 to 45.5'
		☒				SL	17 21 28	26	18/18	100%		SPT #12 46 to 47.5'
			48.8' BOTTOM OF HOLE									
50												

DH1A was drilled right next to DH1B. No field log was prepared for DH1A.

08-29-2005 G:\WATER_PR\PROJECTS\Bob A\Well Logs\Nilan East Dam\Nilan East DH-1B Soil.bor

MONTANA DNRC

WELL COMPLETION LOG NO: DH1A

(Page 1 of 1)

MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/16/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/24/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Drilling	LOGGED BY	: See DH1B Soil Log
DRILLER	:	APPROVED BY	: Brian Grant

Depth In Feet	Surf. Elev. 4452.8
0	
	4452
5	
	4447
10	
	4442
15	
	4437
20	
	4432
25	
	4427
30	
	4422
35	
	4417
40	

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 4/24/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Ed Snyder (ESA)

STANDPIPE

Material	: PVC pipe
Diameter	: 2 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 2 inch
Length	: 5 feet
Opening	: 20 slot

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 8 inch
Length	: 12 inch

NOTES:

Surface Elev: 4452.8 feet (estimate)

DH1A TOP Elev: 4452.23 feet

Top of Cover Elev: 4452.8 feet (estimate)

Northing:

Easting:

Surveyed By: Art Taylor

Date Surveyed: 5/12/1999

DESCRIPTION

0 to 1 OPEN HOLE

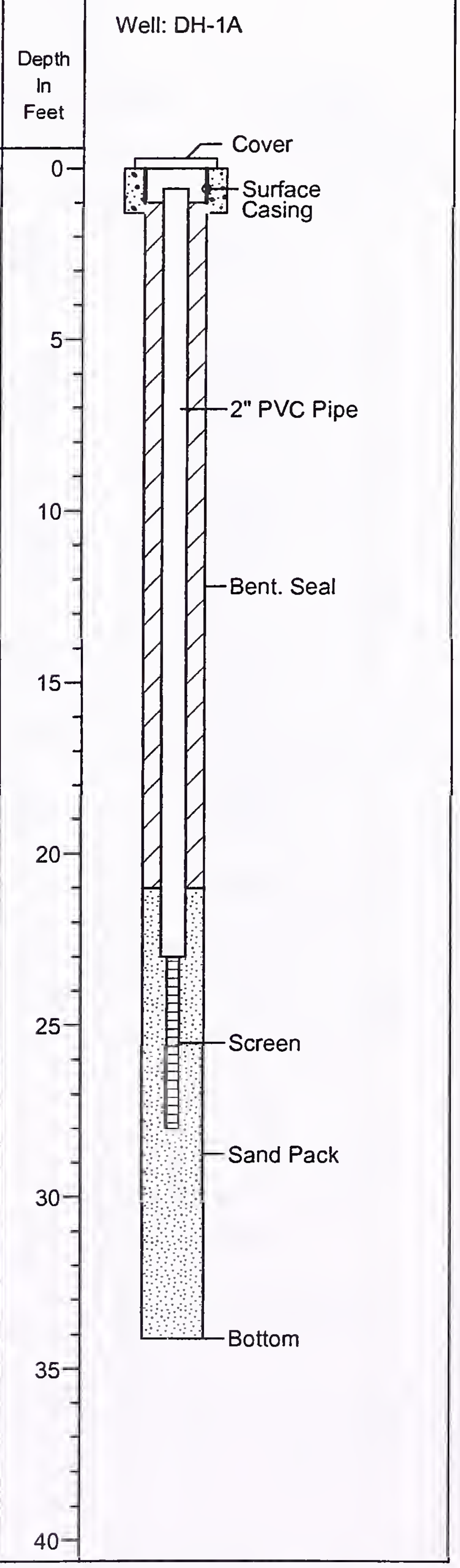
Cover is flush mounted at ground surface with a concrete collar.

1 to 21 BENTONITE

21 to 34.1 SAND PACK

23 to 28 SCREEN FOR DH1A

34.1 BOTTOM OF HOLE



08-29-2005 G:\WATER_PR\PROJECTS\Bob A\Well Logs\Nilan East Dam\Nilan East DH-1A WC.bor

WELL COMPLETION LOG NO: DH1B

(Page 1 of 1)

MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/15/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/15/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Drilling	LOGGED BY	: Ed Snyder (ESA)
DRILLER	:	APPROVED BY	: Brian Grant

Depth In Feet	Surf. Elev. 4452.8
0	4452
5	4447
10	4442
15	4437
20	4432
25	4427
30	4422
35	4417
40	4412
45	4407
50	

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 4/15/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Ed Snyder (ESA)

STANDPIPE

Material	: PVC pipe
Diameter	: 2 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 2 inch
Length	: 5 feet
Opening	: 20 slot

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 8 inch
Length	: 12 inch

NOTES:

Surface Elev: 4452.8 feet (estimate)

DH1B TOP Elev: 4452.41 feet

Top of Cover Elev: 4452.8 feet (estimate)

Northing:

Easting:

Surveyed By: Art Taylor

Date Surveyed: 5/12/1999

DESCRIPTION

0 to 1 OPEN HOLE

Cover is flush mounted at ground surface with a concrete collar.

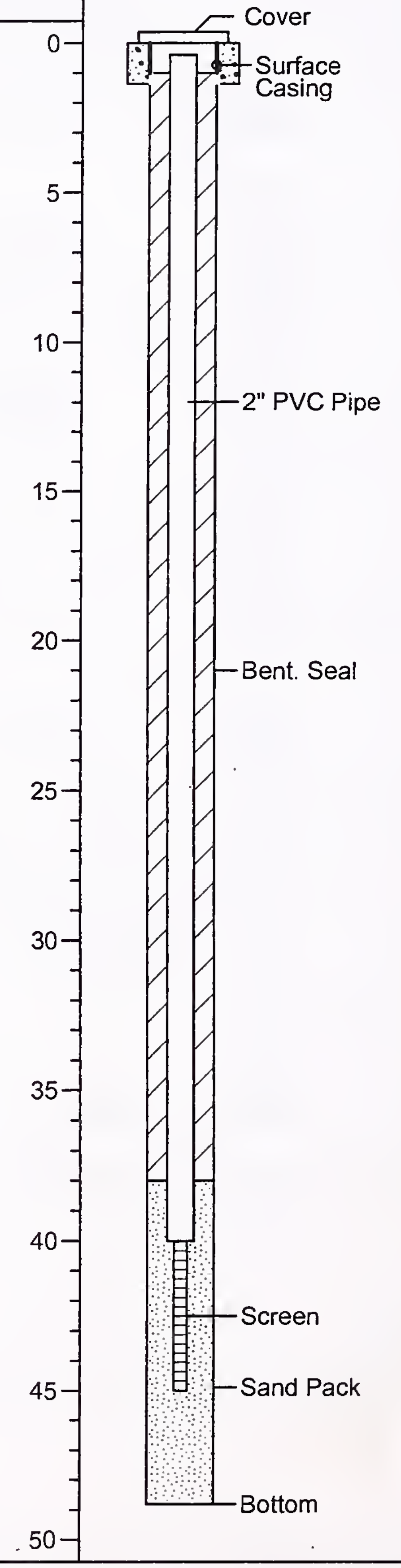
1 to 38 BENTONITE

38 to 48.8 SAND PACK

40 to 45 SCREEN FOR DH1B

48.8 BOTTOM OF HOLE

Well: DH-1B



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MONTANA DNRC

SOIL LOG OF BOREHOLE NO: DH2B

(Page 1 of 2)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6546

RESERVOIR : Nilan East Dam
DATE STARTED : 4/24/1999
DATE COMPLETED : 4/24/1999
DRILL COMPANY : O'Keefe Driling
DRILLER :

DRILL RIG : MB61
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Ed Snyder (ESA)
APPROVED BY : Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4452
0	4452
5	4447
10	4442
15	4437
20	4432
25	4427
30	

Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
	0 to 8' CLAY, slightly sandy, brown, stiff, very moist, calcareous	CL	▨							
	8 to 13' CLAY, sandy gravelly to GRAVEL, sandy clayey (CL/GC). brown, very stiff, very moist, calcareous At 11 to 13' clay is gray	CL	▨							
☒	13 to 28' CLAY, sandy gravelly, brown, very stiff, very moist, calcareous	CL	▨	SS	9 11 14	23	18/18	100%		SPT #1 14 to 15.5'
☒	28 to 31' SAND and GRAVEL	SW	░	SL	9 11 14 18	21	0/24	0%		SPT #2 29 to 31' barrel wet but no water in hole after drive

DH2A was drilled right next to DH2B. No field log was prepared for DH2A.

08-29-2005 WATER_PR\PROJECTS\Bob A\Well Logs\Nilan East Dam\Nilan East DH-2B Soil.bor

SOIL LOG OF BOREHOLE NO: DH2B

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MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/24/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/24/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Driling	LOGGED BY	: Ed Snyder (ESA)
DRILLER	:	APPROVED BY	: Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4452	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
30	4422			SW	░							
		☒	31 to 51.5' CLAY, sandy gravelly, brown, very moist, very stiff	CL	▨	SL	8 16 16 21	21	18/24	75%		SPT #3 31.2 to 33.2' water in hole after drive
35	4417	☒				SS	10 12 13	18	18/18	100%		SPT #4 33.9 to 35.3'
40	4412	☒				SS	12 31 33	42	12/18	66%		SPT #5 39 to 41.5'
45	4407	☒				SS	15 16 18	21	18/18	100%		SPT #6 44 to 45.5'
50	4402	☒				SS	20 31 25	33	13.5/18	75%		SPT #7 49 to 51.5'
			51.5' BOTTOM OF HOLE									
55	4397											
60												

DH2A was drilled right next to DH2B. No field log was prepared for DH2A.

08-29-2005 G:\WATER_PR\PROJECTS\Bob A\Well Logs\Nilan East Dam\Nilan East DH-2B Soil.bor

WELL COMPLETION LOG NO: DH2A

(Page 1 of 1)

MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/25/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/25/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Drilling	LOGGED BY	: See DH2B Soil Log
DRILLER	:	APPROVED BY	: Brian Grant

Depth In Feet	Surf. Elev. 4452
0	4452
5	4447
10	4442
15	4437
20	4432
25	

Well Construction Information

WELL CONSTRUCTION

Date Compl. : 4/25/1999
Hole Diameter : 8 inch
DNRC Rep. : Kevin Smith

STANDPIPE

Material : PVC pipe
Diameter : 2 inch
Joints : screwed
Bottom Cap : glued

WELL SCREEN

Material : PVC pipe
Diameter : 2 inch
Length : 5 feet
Opening : 20 slot

SAND PACK

Material : Colorado Silica 10/20

ANNULUS

Material : 3/8 inch Bentonite

WELL COVER

Diameter : 8 inch
Length : 12 inch

NOTES:

Surface Elev: 4452.8 feet (estimate)

DH2A TOP Elev: 4451.53 feet

Top of Cover Elev: 4452 feet (estimate)

Northing:

Easting:

Surveyed By: Art Taylor

Date Surveyed: 5/12/1999

DESCRIPTION

0 to 1 OPEN HOLE

Cover is 0.8 feet below ground surface so road graders will not hit cover.

1 to 16 BENTONITE

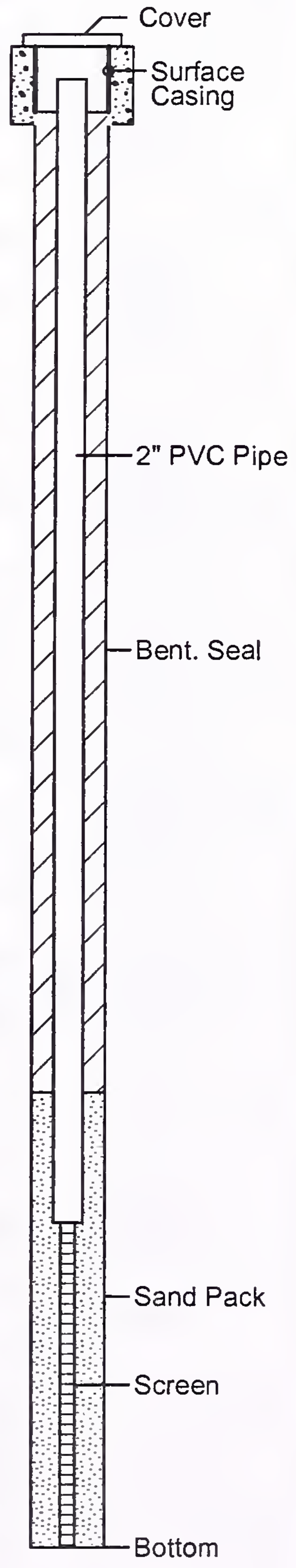
16 to 23 SAND PACK

18 to 23 SCREEN FOR DH2A

23 BOTTOM OF HOLE

Depth In Feet: 0, 5, 10, 15, 20, 25

Well: DH-2A



08-29-2005 WATER_PR\PROJECTS\Bob A\Well Logs\Nilan East Dam\Nilan East DH-2A WC.bor

WELL COMPLETION LOG NO: DH2B

(Page 1 of 1)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/24/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/24/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Drilling	LOGGED BY	: Ed Snyder (ESA)
DRILLER	:	APPROVED BY	: Brain Grant

Depth In Feet	Surf. Elev. 4452
0	4452
5	4447
10	4442
15	4437
20	4432
25	4427
30	4422
35	4417
40	4412
45	4407
50	4402
55	

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 4/24/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Ed Snyder (ESA)

STANDPIPE

Material	: PVC pipe
Diameter	: 2 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 2 inch
Length	: 10 feet
Opening	: 20 slot

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 8 inch
Length	: 12 inch

NOTES:

Surface Elev: 4452.8 feet (estimate)

DH2B TOP Elev: 4451.40 feet

Top of Cover Elev: 4452 feet (estimate)

Northing:

Easting:

Surveyed By: Art Taylor

Date Surveyed: 5/12/1999

DESCRIPTION

0 to 1 OPEN HOLE

Cover is 0.8 feet below ground surface so road graders will not hit cover.

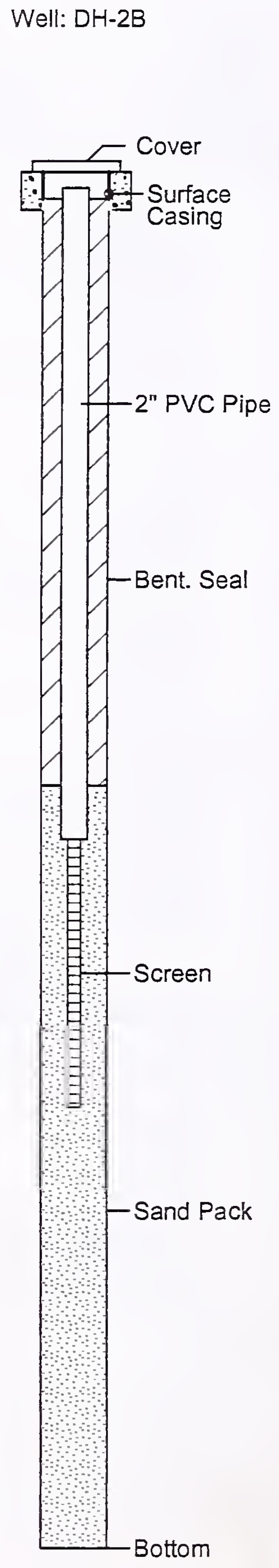
1 to 23 BENTONITE

23 to 51.5 SAND PACK

25 to 35 SCREEN FOR DH2B

51.5 BOTTOM OF HOLE

Depth In Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55



08-29-2005 G:\WATER_PR\PROJECTS\Bob A\Well Logs\Nilan East Dam\Nilan East DH-2B WC.bor

SOIL LOG OF BOREHOLE NO: DH3B

(Page 1 of 2)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan East Dam
DATE STARTED : 4/16/1999
DATE COMPLETED : 4/17/1999
DRILL COMPANY : O'Keefe Driling
DRILLER :

DRILL RIG : MB61
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Ed Snyder (ESA)
APPROVED BY : Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4452.4	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	4452		0 to 30' CLAY, some fine sand, gravelly, brown, stiff to very stiff	CL	▨							
		☒	4 to 30' very moist			SS	4 7 9	28	14.4/18	80%		SPT #1 4 to 5.5'
5	4447											
		☒	10 to 30' gravelly clay			SS	5 7 20	36	18/18	100%		SPT #2 8.7 to 10.2'
10	4442											
		☒	15' very moist, gray brown, very stiff to hard			SS	9 12 17	30	18/18	100%		SPT #3 13.8 to 15.3'
15	4437											
		☒				ST			30/30	100%		SPT #4 15.7 to 18.2'
		☒				SS	11 13 13	23	13.5/18	75%		SPT #5 18.7 to 20.2'
20	4432		20.2' clay, gravelly, yellow brown, moist									
		☒	23.7' clay, brown, gravelly, very moist, very stiff, calcareous			SS	19 14 14	22	18/18	100%		SPT #6 23.7 to 25.2'
25	4427											
		☒	25.5' trace organics (black) plus iron staining, limestone rock fragments at 26.5'			SS	9 11 16	21	18/18	100%		SPT #7 25.5 to 27'
		☒				SS	8 16 12	21	16.2/18	90%		SPT #8 27.1 to 28.6'
		☒				SS	6 13 13	19	18/18	100%		SPT #9 28.7 to 30.2'
30												

DH3A was drilled right next to DH3B. No field log was prepared for DH3A.

08-29-2005 WATER_PR\PROJECTS\Bob A\Well Logs\Nilan East Dam\Nilan East DH-3B Soil.bor

SOIL LOG OF BOREHOLE NO: DH3B

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan East Dam
DATE STARTED : 4/16/1999
DATE COMPLETED : 4/17/1999
DRILL COMPANY : O'Keefe Driling
DRILLER :
DRILL RIG : MB61
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Ed Snyder (ESA)
APPROVED BY : Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4452.4	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
30	4422	☒	30 to 56.5' SANDY CLAY, gravelly, brown, very stiff, very moist, calcareous		▨	SS	12 12 14	19	18/18	100%		SPT #10 30.3 to 31.8'
		☒				SS	17 15 14	21	16.2/18	90%		SPT #11 32.2 to 33.7'
		☒				SS	9 13 15	20	18/18	100%		SPT #12 33.7 to 35.2'
35	4417		36 to 37' rocky drilling									
		☒	39' clay with rock fragments of fine grained sandstone and limestone, minor iron staining			SS	14 16 17	22	16.2/18	90%		SPT #13 38.9 to 40.4'
40	4412											
				CL								
		☒				SS	15 20 20	25	18/18	100%		SPT #14 43.7 to 45.2'
45	4407		46' rocky									
		☒				SS	24 38 41	46	18/18	100%		SPT #15 48.8 to 50.3'
50	4402											
		☒				SS	22 27 50	43	12/18	66%		SPT # 16 53.7 to 55.2' SILTY CLAYEY SAND with GRAVEL (SC-SM) % Finer #200 = 21% % Sand = 51% LL-19% PL=14% PI=5% Double Hydrometer on portion finer #10 Percent Disperstion = 53.33%
55	4397											
			56.5' BOTTOM OF HOLE									
60												

DH3A was drilled right next to DH3B. No field log was prepared for DH3A.

08-29-2005 G:\WATER_PR\PROJECTS\Bob A\Well Logs\Nilan East Dam\Nilan East DH-3B Soil.bor

MONTANA DNRC

WELL COMPLETION LOG NO: DH3A

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan East Dam
DATE STARTED : 4/22/1999
DATE COMPLETED : 4/23/1999
DRILL COMPANY : O'Keefe Drilling
DRILLER :

DRILL RIG : MB61
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : See DH3B Soil Log
APPROVED BY : Brian Grant

Depth In Feet	Surf. Elev. 4452
0	4452
5	4447
10	4442
15	4437
20	4432
25	4427
30	

Well Construction Information

WELL CONSTRUCTION
Date Compl. : 4/23/1999
Hole Diameter : 8 inch
DNRC Rep. : Ed Snyder (ESA)

STANDPIPE
Material : PVC pipe
Diameter : 2 inch
Joints : screwed
Bottom Cap : glued

WELL SCREEN
Material : PVC pipe
Diameter : 2 inch
Length : 5 feet
Opening : 20 slot

SAND PACK
Material : Colorado Silica 10/20

ANNULUS
Material : 3/8 inch Bentonite

WELL COVER
Diameter : 8 inch
Length : 12 inch

NOTES:

Surface Elev: 4452.8 feet (estimate)

DH3A TOP Elev: 4451.37 feet

Top of Cover Elev: 4452 feet (estimate)

Northing:

Easting:

Surveyed By: Art Taylor

Date Surveyed: 5/12/1999

DESCRIPTION

0 to 1 OPEN HOLE

Cover is 0.8 feet below ground surface so road graders will not hit cover.

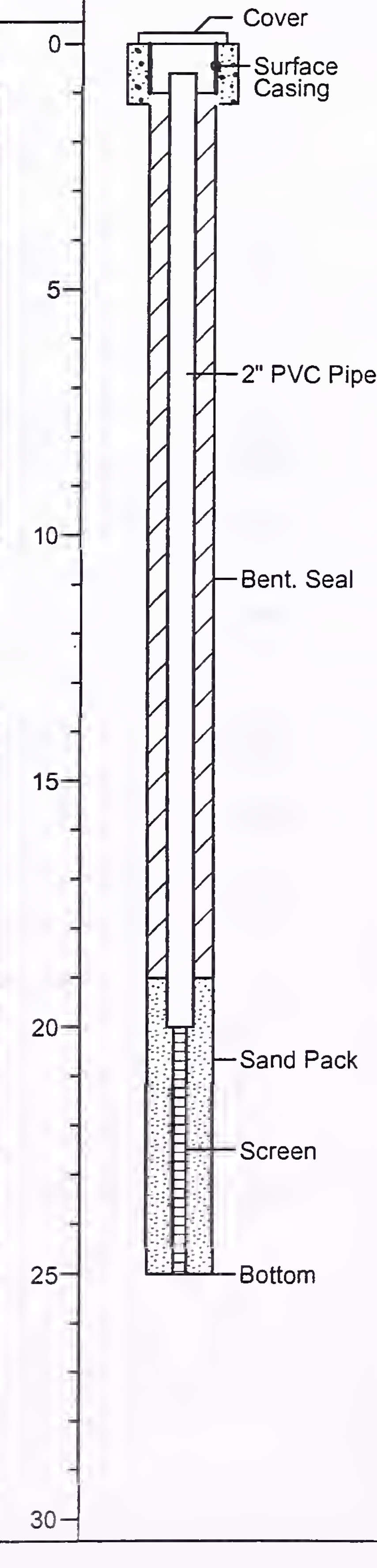
1 to 19 BENTONITE

19 to 25 SAND PACK

20 to 25 SCREEN FOR DH3A

25 BOTTOM OF HOLE

Well: DH-3A



08-29-2005 G:\WATER_PR\PROJECTS\Bob A\Well Logs\Nilan East Dam\Nilan East DH-3A WC.bor

WELL COMPLETION LOG NO: DH3B

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/16/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/17/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Drilling	LOGGED BY	: Ed Snyder (ESA)
DRILLER	:	APPROVED BY	: Brian Grant

Depth In Feet	Surf. Elev. 4452.4
0	4452
5	4447
10	4442
15	4437
20	4432
25	4427
30	4422
35	4417
40	4412
45	4407
50	4402
55	4397
60	

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 4/17/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Ed Snyder (ESA)

STANDPIPE

Material	: PVC pipe
Diameter	: 2 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 2 inch
Length	: 10 feet
Opening	: 20 slot

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 8 inch
Length	: 12 inch

NOTES:

Surface Elev: 4452.8 feet (estimate)

DH3B TOP Elev: 4451.89 feet

Top of Cover Elev: 4452 feet (estimate)

Northing:

Easting:

Surveyed By: Art Taylor

Date Surveyed: 5/12/1999

DESCRIPTION

0 to 1 OPEN HOLE

Cover is 0.8 feet below ground surface so road graders will not hit cover.

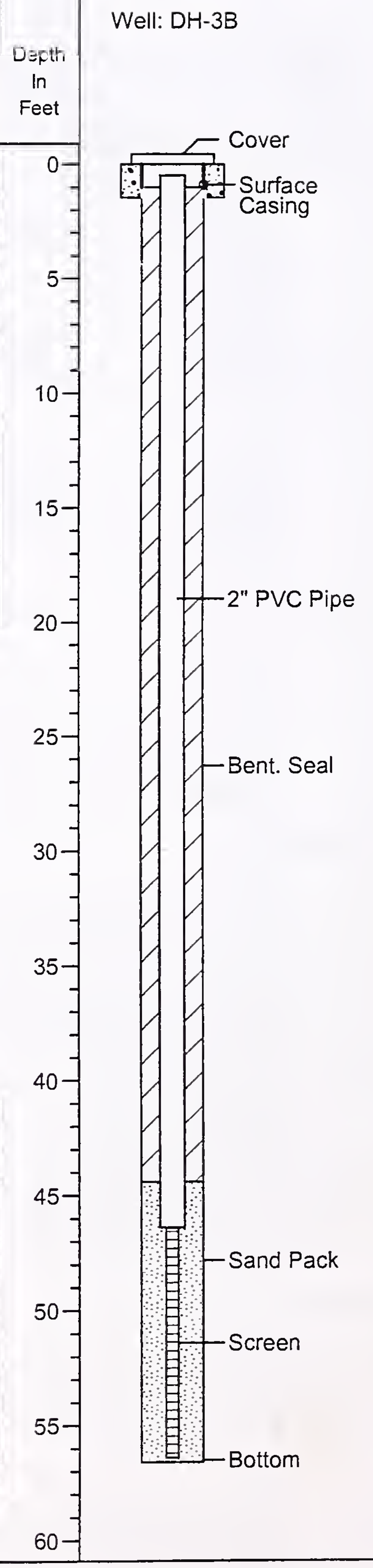
1 to 44.4 BENTONITE

44.4 to 56.5 SAND PACK

46.4 to 56.4 SCREEN FOR DH3B

56.5 BOTTOM OF HOLE

Depth In Feet



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SOIL LOG OF BOREHOLE NO: DH4

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/17/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/17/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Driling	LOGGED BY	: Ed Snyder (ESA)
DRILLER	:	APPROVED BY	: Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4452	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	4452		0 to 1' ROAD BASE - clay and gravel	GC	░							
			1 to 8' CLAY, slightly sandy, gravelly, brown, stiff, very moist, calcareous	CL	▨							
5	4447											
												8 to 10' rocky drilling
		☒	8 to 10' CLAYEY GRAVEL, sandy, brown, medium dense to dense, very moist, calcareous	GC	░	SS	18 22 25	49	12/18	66%		SPT #1 8.6 to 10.1'
10	4442		10 to 25' CLAY, sandy, gravelly, brown, very stiff, very moist, calcareous, some limestone fragments	CL	▨							
		☒				SS	12 17 18	33	18/18	100%		SPT #2 13.6 to 15.1'
15	4437											
		☒	17' Foundation contact (estimated). Two silty/sandy lenses 2" thick, trace plant parts			SS	16 16 16	28	18/18	100%		SPT #3 16.1 to 17.6'
		☒	19 to 19.6' CLAY, silty, sandy, gravelly, brown to yellow brown, some minor iron staining			SS	10 12 28	32	12/18	66%		SPT #4 18.6 to 20.1'
20	4432											
		☒				SL	18 16 18 20	26	24/24	100%		SPT #5 20.7 to 22.7'
25												

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SOIL LOG OF BOREHOLE NO: DH4

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan East Dam
DATE STARTED : 4/17/1999
DATE COMPLETED : 4/17/1999
DRILL COMPANY : O'Keefe Driling
DRILLER :

DRILL RIG : MB61
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Ed Snyder (ESA)
APPROVED BY : Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4452	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
25	4427		25 to 27' CLAYEY GRAVEL, sandy, medium dense to dense,yellow brown - gray brown, moist	GC								
			27 to 29' SANDY CLAY, gravelly, yellow brown, very stiff, very moist,calcareous	CL								
		☒				SS	18 21 22	31	18/18	100%		SPT #6 28.7 to 30.2'
30	4422		29 to 31' CLAYEY GRAVEL,sandy, medium dense to dense, yellow brown - gray brown, moist	GC								
			31 to 40.2' SANDY CLAY, gravelly, light yellow brown, very stiff, very moist, calcareous	CL								
		☒				SS	11 16 22	27	18/18	100%		SPT #7 33.7 to 35.2'
35	4417											
		☒				SS	44 22 21	28	18/18	100%		SPT #8 38.7 to 40.2'
40	4412		40.2' BOTTOM OF HOLE									
45	4407											
50												

WELL COMPLETION LOG NO: DH4

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan East Dam
DATE STARTED : 4/17/1999
DATE COMPLETED : 4/17/1999
DRILL COMPANY : O'Keefe Drilling
DRILLER :

DRILL RIG : MB61
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Ed Snyder
APPROVED BY : Brian Grant

Depth In Feet	Surf. Elev. 4452
0	4452
5	4447
10	4442
15	4437
20	4432
25	4427
30	4422
35	4417
40	4412
45	

Well Construction Information

WELL CONSTRUCTION
Date Compl. : 4/17/1999
Hole Diameter : 8 inch
DNRC Rep. : Ed Snyder (ESA)

STANDPIPE
Material : PVC pipe
Diameter : 2 inch
Joints : screwed
Bottom Cap : glued

WELL SCREEN
Material : PVC pipe
Diameter : 2 inch
Length : 10 feet
Opening : 20 slot

SAND PACK
Material : Colorado Silica 10/20

ANNULUS
Material : 3/8 inch Bentonite

WELL COVER
Diameter : 8 inch
Length : 12 inch

NOTES:

Surface Elev: 4452.8 feet (estimate)

DH4 TOP Elev: 4451.00 feet

Top of Cover Elev: 4452 feet (estimate)

Northing:

Easting:

Surveyed By: Art Taylor

Date Surveyed: 5/12/1999

DESCRIPTION

0 to 1 OPEN HOLE

Cover is located 0.8 feet below ground surface so road graders will not hit cover.

1 to 25 BENTONITE

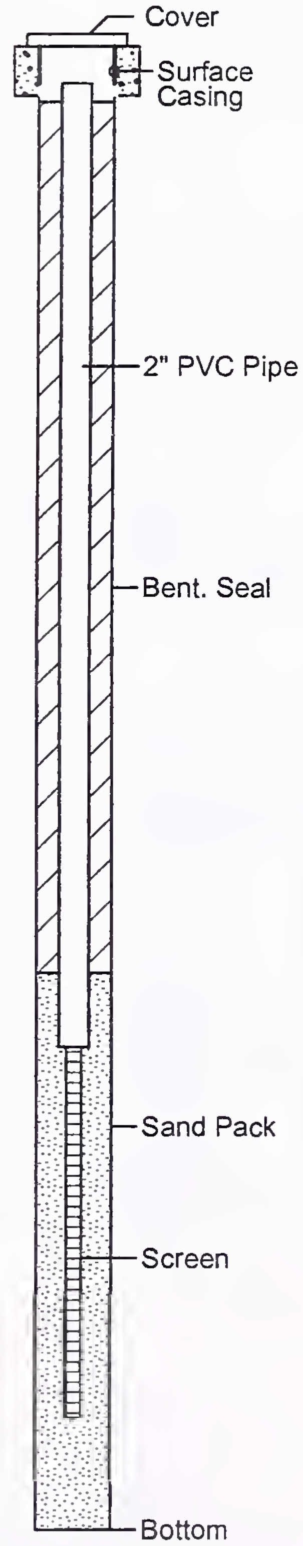
25 to 40 SAND PACK

27 to 37 SCREEN FOR DH4

40.2 BOTTOM OF HOLE

Depth In Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45

Well: DH-4



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SOIL LOG OF BOREHOLE NO: DH5B

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan East Dam
DATE STARTED : 4/21/1999
DATE COMPLETED : 4/22/1999
DRILL COMPANY : O'Keefe Driling
DRILLER :

DRILL RIG : MB61
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Ed Snyder (ESA)
APPROVED BY : Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4452	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd / Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	4452		0 to 1' ROAD BASE - clay and gravel	GC	▩							
			1 to 5' CLAY, slightly sandy, brown, stiff, very moist, calcareous	CL	▨							
5	4447		5 to 34.5' SANDY LEAN CLAY, gravelly, mixed brown, yellow brown and gray brown, very stiff to hard, very moist, calcareous, sandstone and limestone fragments		▨							
		☒	9' gravelly clay, brown		▨	SS	14 21 22	44	18/18	100%		SPT #1 9 to 10.5'
10	4442				▨							
15	4437				▨							
				CL	▨							
20	4432	☒			▨	SL	8 12 15 16	20	18/24	75%		SPT #2 19 to 21' % Finer #200 = 52% LL=30% PL=15% PI=15% % Sand = 34% Dry Unit Weight = 102.5 pcf
25	4427				▨							
		☒			▨	SL	8 16 22 34	24	24/24	100%		SPT #3 29 to 31'
30												

DH5A was drilled right next to DH5B. No field log was prepared for DH5A.

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SOIL LOG OF BOREHOLE NO: DH5B

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan East Dam
DATE STARTED : 4/21/1999
DATE COMPLETED : 4/22/1999
DRILL COMPANY : O'Keefe Driling
DRILLER :

DRILL RIG : MB61
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Ed Snyder (ESA)
APPROVED BY : Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4452	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
30	4422			CL								
35	4417	☒	34.5 to 38' TOPSOIL, clay, fine sand, organic with root fragments, black, moist	TS		SL	10 12 10 12	14	24/24	100%		SPT #4 34 to 36' 34.5' foundation contact (estimated)
40	4412	☒	38 to 45.5' LEAN CLAY, brown, firm to stiff, very moist, calcareous, some limestone fragments 38 to 41' with sand	CL		SS	4 4 6	7	18/18	100%		SPT #5 39 to 40.5' % Finer #200 = 83% LL=39% PL=17% PI=22%
45	4407	☒				SL	6 8 11 32	10	21.6/24	90%		SPT #6 44 to 46' % Finer #200 = 90% Double Hydrometer Percent Dispersion = 27.3%
			45.5 to 54.3' CLAYEY SAND with gravel, brown, very stiff - hard, very moist, calcareous	SC								
50	4402	☒				SS	11 19 26	26	12/18	66%		SPT #7 49 to 50.5'
		☒				SL	24 22 24 31	23	24/24	100%		SPT #8 52.3 to 54.3' % Finer #200 = 44.34% % Gravel = 24% Dry Unit Weight = 130.6 pcf
55	4397		54.3' BOTTOM OF HOLE									
60												

DH5A was drilled right next to DH5B. No field log was prepared for DH5A.

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WELL COMPLETION LOG NO: DH5A

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MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan East Dam
DATE STARTED : 4/22/1999
DATE COMPLETED : 4/22/1999
DRILL COMPANY : O'Keefe Drilling
DRILLER :

DRILL RIG : MB61
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : See DH5B Soil Log
APPROVED BY : Brian Grant

Depth In Feet	Surf. Elev. 4452
0	4452
5	4447
10	4442
15	4437
20	4432
25	4427
30	4422
35	

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 4/22/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Ed Snyder (ESA)

STANDPIPE

Material	: PVC pipe
Diameter	: 2 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 2 inch
Length	: 5 feet
Opening	: 20 slot

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 8 inch
Length	: 12 inch

NOTES:

Surface Elev: 4452.8 feet (estimate)

DH5A TOP Elev: 4451.09 feet

Top of Cover Elev: 4452 feet (estimate)

Northing:

Easting:

Surveyed By: Art Taylor

Date Surveyed: 5/12/1999

DESCRIPTION

0 to 1 OPEN HOLE

Cover is 0.8 feet below ground surface so road graders will not hit cover.

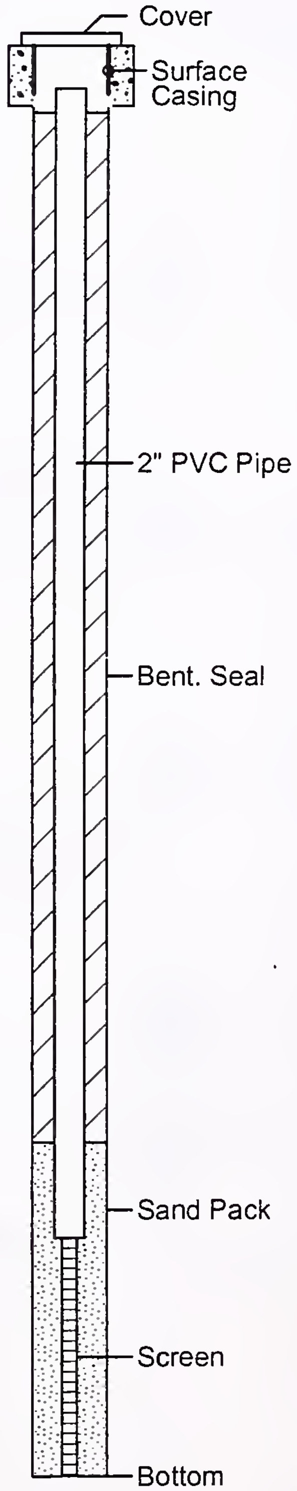
1 to 23 BENTONITE

23 to 30 SAND PACK

25 to 30 SCREEN FOR DH5A

30 BOTTOM OF HOLE

Well: DH-5A



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WELL COMPLETION LOG NO: DH5B

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/21/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/22/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Drilling	LOGGED BY	: Ed Snyder (ESA)
DRILLER	:	APPROVED BY	: Brian Grant

Depth in Feet	Surf. Elev. 4452
0	4452
5	4447
10	4442
15	4437
20	4432
25	4427
30	4422
35	4417
40	4412
45	4407
50	4402
55	

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 4/22/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Ed Snyder (ESA)

STANDPIPE

Material	: PVC pipe
Diameter	: 2 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 2 inch
Length	: 10 feet
Opening	: 20 slot

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 8 inch
Length	: 12 inch

NOTES:

Surface Elev: 4452.8 feet (estimate)

DH5B TOP Elev: 4450.82 feet

Top of Cover Elev: 4452 feet (estimate)

Northing:

Easting:

Surveyed By: Art Taylor

Date Surveyed: 5/12/1999

DESCRIPTION

0 to 1 OPEN HOLE

Cover is 0.8 feet below ground surface so road graders will not hit cover.

1 to 38 BENTONITE

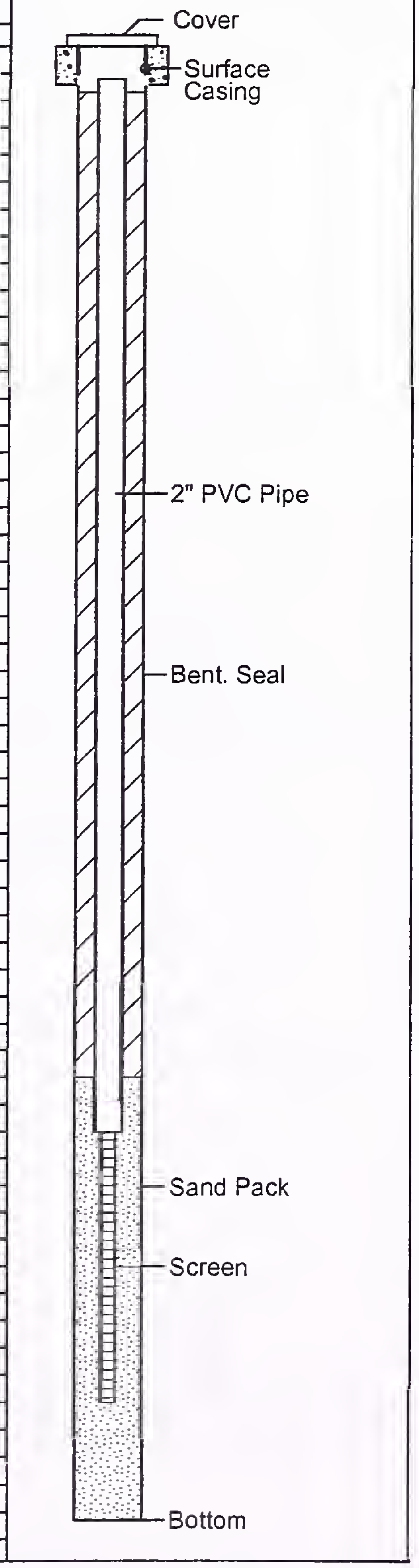
38 to 54.3 SAND PACK

40 to 50 SCREEN FOR DH5B

54.3 BOTTOM OF HOLE

Depth in Feet

Well: DH-5B



08-29-2005 WATER_PR\PROJECTS\Bob A\Well Logs\Nilan East Dam\Nilan East DH-5B WC.bor

SOIL LOG OF BOREHOLE NO: DH6B

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MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/20/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/21/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Driling	LOGGED BY	: Ed Snyder (ESA)
DRILLER	:	APPROVED BY	: Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4433	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	4433		0 to 1' TOP SOIL									
		☒	1 to 7' SANDY CLAY, gravelly, brown, stiff to very stiff, very moist, slightly calcareous	CL		SS	6 8 9	28	12/18	66%		
5	4428											
			7 to 9' SAND and GRAVEL, medium dense, water zone	SW								Set piezometer 6A to intercept sand and gravel zone.
		☒	9 to 11' CLAY, sandy, gravelly, brown, very moist, very stiff	CL		SL	12 12 16 22	27	24/24	100%		
10	4423											
			11 to 29' SAND, gravelly, medium dense, gray-olive brown, saturated 14' sand and gravel heaved 3' when auger plug pulled	SW								
15	4418											
		☒				SS	8 17 9	21	12/18	66%		
20												

DH6A was drilled right next to DH6B. No field log was prepared for DH6A.

SOIL LOG OF BOREHOLE NO: DH6B

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/20/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/21/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Driling	LOGGED BY	: Ed Snyder (ESA)
DRILLER	:	APPROVED BY	: Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4433	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd / Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
20	4413											
25	4408	☒		SW	▒	SL	8 12 20 26	23	24/24	100%		
30	4403	☒	29 to 33' CLAYEY SAND with gravel, medium dense to dense, gray brown, saturated	SC	▨	SL	9 16 19 22	23	24/24	100%		28.5 to 30.5' % Finer #200 = 31% % gravel = 18% Dry Unit Weight = 135.6 pcf
			32 to 33' rocky drillings									
35	4398	☒	33 to 69' SANDY CLAY, gravelly, brown-yellow brown, very stiff to hard,very moist, some iron stain streaks	CL	▨	SS	17 18 22	28	12/18	66%		
40												

DH6A was drilled right next to DH6B. No field log was prepared for DH6A.

08-29-2005 \\WATER_PR\PROJECTS\Bob A\Well Logs\Nilan East Dam\Nilan East DH-6B Soil.bor

MONTANA DNRC

SOIL LOG OF BOREHOLE NO: DH6B

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/20/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/21/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Driling	LOGGED BY	: Ed Snyder (ESA)
DRILLER	:	APPROVED BY	: Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4433	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
40	4393											
		☒				SL	13 19 27 32	25	0/24	0%		
45	4388											
		☒				SL	12 14 19 33	18	7.2/24	30%		
50	4383			CL								
		☒				SS	15 16 18	19	18/18	100%		
55	4378											
60												

DH6A was drilled right next to DH6B. No field log was prepared for DH6A.

MONTANA DNRC

SOIL LOG OF BOREHOLE NO: DH6B

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/20/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/21/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Driling	LOGGED BY	: Ed Snyder (ESA)
DRILLER	:	APPROVED BY	: Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4433	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
60	4373											
		☒		CL	▨	SS	12 14 18	16	18/18	100%		
65	4368											
		☒	69 to 74' SAND and GRAVEL, dense, gray and black mix, saturated	SW	░	SS	25 30 32	31	18/18	100%		
70	4363											
		☒	74 to 76.6' CLAYEY SAND, gravelly, mixed gray, brown and yellow brown, dense to very dense, very moist, scattered pink rock fragments	SC	▨	SS	18 27 29	27	18/18	100%		
75	4358											
			76.6' BOTTOM OF HOLE									
80												

DH6A was drilled right next to DH6B. No field log was prepared for DH6A.

WELL COMPLETION LOG NO: DH6A

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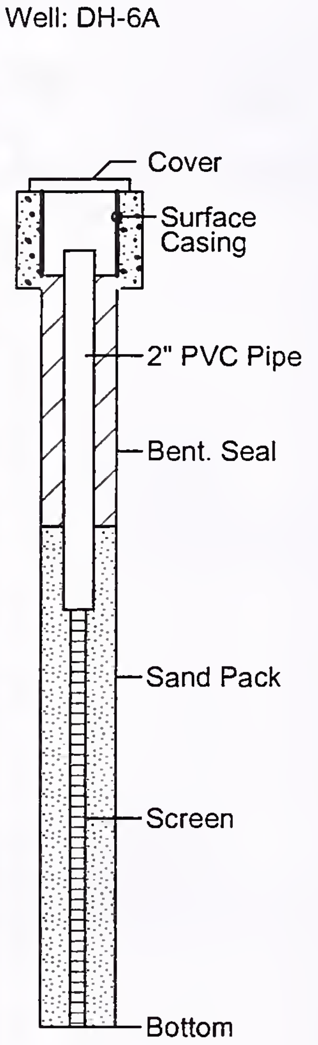
MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/20/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/20/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Drilling	LOGGED BY	: See DH6B Soil Log
DRILLER	:	APPROVED BY	: Brian Grant

Depth In Feet	Surf. Elev. 4432.7	Well Construction Information	DESCRIPTION	Depth In Feet
0	4432	**WELL CONSTRUCTION** Date Compl. : 4/20/1999 Hole Diameter : 8 inch DNRC Rep. : Ed Snyder (ESA) **STANDPIPE** Material : PVC pipe Diameter : 2 inch Joints : screwed Bottom Cap : glued	0 to 1 OPEN HOLE Cover is mounted several inches above ground surface within a concrete collar. 1 to 4 BENTONITE	0
5	4427	**WELL SCREEN** Material : PVC pipe Diameter : 2 inch Length : 5 feet Opening : 20 slot **SAND PACK** Material : Colorado Silica 10/20 **ANNULUS** Material : 3/8 inch Bentonite **WELL COVER** Diameter : 8 inch Length : 12 inch	4 to 10 SAND PACK 5 to 10 SCREEN FOR DH6A	5
10	4422	**NOTES:** Top of Cover Elev: 4433 feet (estimate) Surface Elev: 4432.7 feet (estimate) DH6A TOP Elev: 4432.01 feet Northing: Easting: Surveyed By: Art Taylor Date Surveyed: 5/12/1999	10 BOTTOM OF HOLE	10
15	4417			15
20				20



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WELL COMPLETION LOG NO: DH6B

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/20/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/21/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Drilling	LOGGED BY	: Ed Snyder (ESA)
DRILLER	:	APPROVED BY	: Brian Grant

Depth In Feet	Surf. Elev. 4433
0	4433
5	4428
10	4423
15	4418
20	4413
25	4408
30	4403
35	4398
40	4393
45	4388
50	4383
55	4378
60	4373
65	4368
70	4363
75	4358
80	

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 4/21/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Ed Snyder (ESA)

STANDPIPE

Material	: PVC pipe
Diameter	: 2 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 2 inch
Length	: 5 feet
Opening	: 20 slot

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 8 inch
Length	: 12 inch

NOTES:

Top of Cover Elev: 4433 feet (estimate)

Surface Elev: 4433 feet (estimate)

DH6B TOP Elev: 4432.52 feet

Northing:

Easting:

Surveyed By: Art Taylor

Date Surveyed: 5/12/1999

DESCRIPTION

0 to 1 OPEN HOLE

Cover is flush mounted at ground surface with a concrete collar.

1 to 69.4 BENTONITE SLURRY

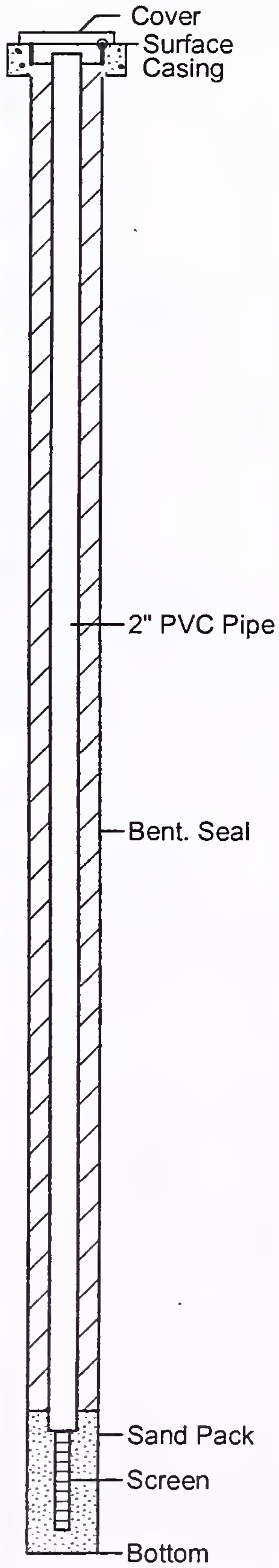
69.4 to 76.6 SAND PACK

70.4 to 75.4 SCREEN FOR DH6B

76.6 BOTTOM OF HOLE

Depth In Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80

Well: DH-6B



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SOIL LOG OF BOREHOLE NO: DH7B

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan East Dam
DATE STARTED : 4/19/1999
DATE COMPLETED : 4/19/1999
DRILL COMPANY : O'Keefe Driling
DRILLER :

DRILL RIG : MB61
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Ed Snyder (ESA)
APPROVED BY : Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4432.8	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow COunts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	4432		0 to 1' TOP SOIL									
5	4427	☒	1 to 6.5' CLAYEY GRAVEL, sandy with cobbles and boulders, brown, very moist, calcareous	GC		SS	10 50+		3.4/10.2	33%		Sampler stopped on rock sandstone fragment in tip
10	4422	☒	6.5 to 40.8' SANDY CLAY, gravelly, brown to yellow brown, very moist, some iron stained streaks 6.5 to 11' scattered cobbles	CL		SL	14 15 34 50+	45	18/24	75%		
15	4417	☒	11 to 29.5' brown to dark brown, very moist, very stiff to hard, calcareous			SS	12 20 26	43	18/18	100%		
20	4412	☒				SS	18 26 32	46	4/18	20%		Sampler drive on rock 4 " recovered
25		☒				SS	14 16 23	31	18/18	100%		23 blow count thru rock fragment

DH7A was drill right next to DH7B. No field log was prepared for DH7A.

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SOIL LOG OF BOREHOLE NO: DH7B

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/19/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/19/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Driling	LOGGED BY	: Ed Snyder (ESA)
DRILLER	:	APPROVED BY	: Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4432.8	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow COunts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
25												
	4407											
30		☒	29.5 to 40.8' gray brown, very stiff to hard, very moist, non-calcareous	CL	▨	SS	12 20 25	32	18/18	100%		pink sandstone fragments in sample
	4402											
35		☒				SL	26 50+		2.4/24	10%		Sampler on rock at 34.5'
	4397											
40		☒				SS	8 11 17	18	18/18	100%		
	4392		40.8' BOTTOM OF HOLE									
45												
	4387											
50												

DH7A was drill right next to DH7B. No field log was prepared for DH7A.

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WELL COMPLETION LOG NO: DH7A

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/19/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/19/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Drilling	LOGGED BY	: See DH7B Soil Log
DRILLER	:	APPROVED BY	: Brian Grant

Depth In Feet	Surf. Elev. 4432.5
0	4432
5	4427
10	4422
15	4417
20	

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 4/19/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Ed Snyder (ESA)

STANDPIPE

Material	: PVC pipe
Diameter	: 2 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 2 inch
Length	: 5 feet
Opening	: 20 slot

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 8 inch
Length	: 12 inch

NOTES:

Top of Cover Elev: 4432.8 feet (estimate)

Surface Elev: 4432.5 feet (estimate)

DH7A TOP Elev: 4431.84 feet

Northing:

Easting:

Surveyed By: Art Taylor

Date Surveyed: 5/12/1999

DESCRIPTION

0 to 1 OPEN HOLE

Cover is mounted several inches above ground surface within a concrete collar.

1 to 8 BENTONITE

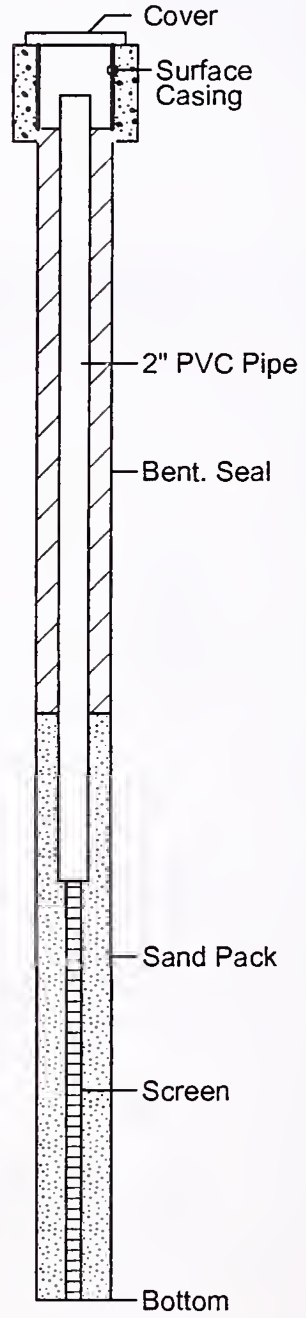
8 to 15 SAND PACK

10 to 15 SCREEN FOR DH7A

15 BOTTOM OF HOLE

Depth In Feet: 0, 5, 10, 15, 20

Well: DH-7A



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WELL COMPLETION LOG NO: DH7B

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MT DEPARTMENT OF NATURAL
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P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 4/19/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 4/19/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Drilling	LOGGED BY	: Ed Snyder (ESA)
DRILLER	:	APPROVED BY	: Brian Grant

Depth In Feet	Surf. Elev. 4432.8
0	4432
5	4427
10	4422
15	4417
20	4412
25	4407
30	4402
35	4397
40	4392
45	4387
50	

Well Construction Information

WELL CONSTRUCTION

Date Compl. : 4/19/1999
Hole Diameter : 8 inch
DNRC Rep. : Ed Snyder (ESA)

STANDPIPE

Material : PVC pipe
Diameter : 2 inch
Joints : screwed
Bottom Cap : glued

WELL SCREEN

Material : PVC pipe
Diameter : 2 inch
Length : 10 feet
Opening : 20 slot

SAND PACK

Material : Colorado Silica 10/20

ANNULUS

Material : 3/8 inch Bentonite

WELL COVER

Diameter : 8 inch
Length : 12 inch

NOTES:

Top of Cover Elev: 4432.8 feet (estimate)

Surface Elev: 4432.8 feet (estimate)

DH7B TOP Elev: 4432.32 feet

Northing:

Easting:

Surveyed By: Art Taylor

Date Surveyed: 5/12/1999

DESCRIPTION

0 to 1 OPEN HOLE

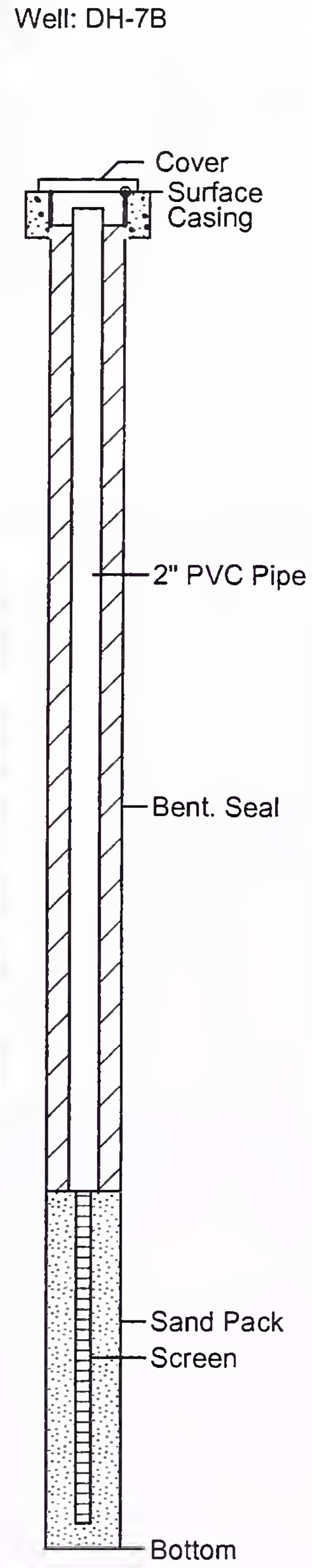
Cover is flush mounted at ground surface with a concrete collar.

1 to 30 BENTONITE

30 to 40.8 SAND PACK

30 to 40 SCREEN FOR DH7B

40.8 BOTTOM OF HOLE



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SOIL LOG OF BOREHOLE NO: DH8

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan East Dam
DATE STARTED : 11/7/1999
DATE COMPLETED : 11/9/1999
DRILL COMPANY : Bush Driling
DRILLER :

DRILL RIG : Strata Star 15
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Bob Arrington
APPROVED BY : Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4431.3	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	4431		0 to 30' CLAYEY GRAVEL, light brown, dry to slightly moist		▨							
5	4426				▨							
10	4421			GC	▨							
15	4416				▨							
20	4411				▨							
25												

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SOIL LOG OF BOREHOLE NO: DH8

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: Strata Star 15
DATE STARTED	: 11/7/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 11/9/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Driling	LOGGED BY	: Bob Arrington
DRILLER	:	APPROVED BY	: Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4431.3	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd / Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
25	4406			GC								
30	4401	☒	30 to 40' CLAY, some gravel, light brown, stiff, dry to slightly moist, sandstone fragments			SS	12 19 35	46	13.2/18	73%		SPT #1 30 to 31.5'
35	4396		+/- 35' gravel zone 3/8 to 3/4 rounded	CL								
40	4391	☒	40 to 45' CLAYEY SAND, gravelly, light brown to brown, stiff, very moist, calcareous, sandstone and limestone fragments	SC		SS	7 10 39	36	12/18	66%		SPT #2 40 to 41.5' % Finer #200 = 44% Percent Dispersion = 34.64%
45	4386		45 to 55' SILTY SAND, gravelly, dry, cohesionless, shale and argilite fragments	SM								
50												

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SOIL LOG OF BOREHOLE NO: DH8

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MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: Strata Star 15
DATE STARTED	: 11/7/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 11/9/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Driling	LOGGED BY	: Bob Arrington
DRILLER	:	APPROVED BY	: Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4431.3	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
50	4381	☒		SM		SL	40 31 29	36	16.8/18	93%		SPT #3 50 to 51.5' % Finer #200 = 12% m = 5.31% Dry Unit Weight = 116.4 pcf Moist Unit Weight = 122.5 pcf
55	4376		55 to 65' POORLY GRADED GRAVEL, with silt and sand, brown, slightly moist to moist, some sandstones cobble and pieces	GP								
60	4371	☒				SL	43 52 37	49	16.8/18	93%		SPT #4 60 to 61.5' % Finer #200 = 10% GP-GM
65	4366		65 to 95' WELL GRADED SAND with silt and gravel, brown, saturated, medium dense	SW								65 to 70' no cuttings
70	4361	☒				SL	3 9 23	16	18/18	100%		SPT #5 70 to 71.5' % Finer #200 = 9% Sand heaved approximately 1' 70 to 75' pushed auger without augering
75												

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SOIL LOG OF BOREHOLE NO: DH8

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan East Dam
DATE STARTED : 11/7/1999
DATE COMPLETED : 11/9/1999
DRILL COMPANY : Bush Driling
DRILLER :

DRILL RIG : Strata Star 15
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Bob Arrington
APPROVED BY : Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4431.3	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
75	4356											75 to 80' pushed auger with 0 torque on augers
80	4351											80 to 95' very easy augering
85	4346			SW								
90	4341											
			94 to 95' sity sand, fine grained									94 to 95' Driller noted material got slightly harder. Raised center plug and lowered it without heave. Decided to sample.
95	4336	☒	95' BOTTOM OF HOLE			SL	16 22 39	27	5.4/18	30%		SPT #6 95 to 91.5' Sandstone rock in shoe of sampler.
100												

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WELL COMPLETION LOG NO: DH8

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: Strata Star 15
DATE STARTED	: 11/7/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 11/9/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Bob Arrington
DRILLER	:	APPROVED BY	: Brian Grant

Depth In Feet	Surf. Elev. 4430.9	DESCRIPTION	Depth In Feet
0	4430	0 to 5 SAND	0
5	4425	Sand inside casing Concrete outside casing 5 to 40 BENTONITE	5
10	4420		10
15	4415		15
20	4410		20
25	4405		25
30	4400		30
35	4395		35
40	4390	40 to 50 SAND	40
45	4385	44 to 49 DH8B SCREEN	45
50	4380	50 to 65 BENTONITE	50
55	4375		55
60	4370		60
65	4365	65 to 95 HOLE CAVED NATURAL SAND	65
70	4360		70
75	4355		75
80	4350		80
85	4345	82.5 to 92.5 DH8A SCREEN	85
90	4340		90
95	4335	95 BOTTOM OF HOLE	95
100			100

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 11/9/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Bob Arrington

STANDPIPE

Material	: PVC pipe
Diameter	: 1 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 1 inch
Length	: 5 feet
Opening	: .02 inch

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 6 inch
Length	: 5 feet

NOTES:

Surface Elev: 4430.93 feet

DH8A TOP Elev: 4431.56 feet

DH8B TOP Elev: 4431.74 feet

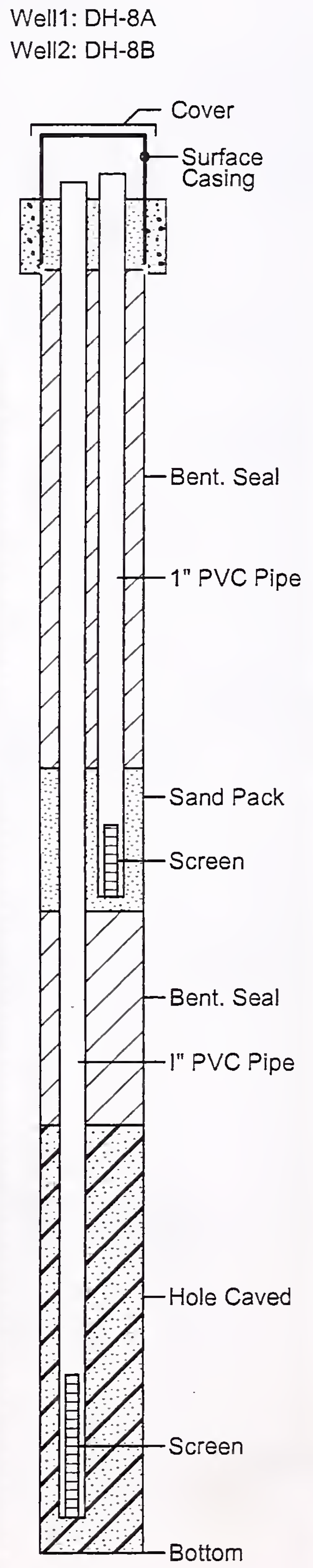
Top of Cover Elev: 4431.92 feet

Northing: 9936.48

Easting: 9415.81

Surveyed By: Jim Beck

Date Surveyed: 6/5/2002



SOIL LOG OF BOREHOLE NO: DH9

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan East Dam
DATE STARTED : 11/27/2000
DATE COMPLETED : 11/29/2000
DRILL COMPANY : O'Keefe Driling
DRILLER :

DRILL RIG : MB61
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Kevin Smith
APPROVED BY : Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4432	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	4432		0 to 1' TOPSOIL/ROOT MATERIAL	GC								
			1 to 7' CLAYEY SAND with silt and gravel, brown, dry. Gravel mostly rounded, 1.5" to pea size, high concentration of pea gravel.	SC								
5	4427	☒				SL	24 25 19	55	15/18	83%		SPT #1 5 to 6.5'
			7 to 42' GRAVELLY CLAY, some fine sand, brown, very stiff to stiff, slightly moist, slightly plastic	GC								
10	4422											
15	4417	☒				SL	10 27 34	50	9/18	50%		SPT #2 15 to 16.5'
20	4412											
25												

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SOIL LOG OF BOREHOLE NO: DH9

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 11/27/2000	DRILLING METHOD	: Auger
DATE COMPLETED	: 11/29/2000	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Driling	LOGGED BY	: Kevin Smith
DRILLER	:	APPROVED BY	: Brian Grant

SAMPLER TYPE
- SS Split spoon
- SL Split Spoon Brass Liners
- ST Shelby Tube

Depth in Feet	Surf. Elev. 4432	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd / Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
25	4407	☒		GC	▨	SL	27 28 38	47	14/18	77%		SPT #3 25 to 26.5'
30	4402				▨							
35	4397	☒			▨	SL	27 50		2/18	11%		SPT #4 35 to 36.5' Rock lodged in liner
40	4392				▨							
			42 to 60' SILTY GRAVEL with sand, dense, slightly moist. Gravel mostly less than 1.5", mostly rounded.	GM	░							
45	4387	☒			░	SL	50 40 42	46	15/18	83%		SPT #5 45 to 46.5'
50					░							

SOIL LOG OF BOREHOLE NO: DH9

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MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan East Dam
DATE STARTED : 11/27/2000
DATE COMPLETED : 11/29/2000
DRILL COMPANY : O'Keefe Driling
DRILLER :

DRILL RIG : MB61
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Kevin Smith
APPROVED BY : Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4432	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
50	4382											
55	4377	☒		GM		SL	44 50		7/18	39%		SPT #6 55 to 56.5' Three or so broken rocks in liner
60	4372	☒	60 to 63' SILTY SAND, brown, slightly moist to moist, some 1" rocks	SM		SL	34 50		9/18	50%		SPT #7 60 to 61.5'
			63 to 70' CLAYEY GRAVEL with rocks, brown, slightly moist to moist, medium dense									
65	4367	☒		GC		SL	40 50		11/18	61%		SPT #8 65 to 66.5'
70	4362	☒	70' BOTTOM OF HOLE Sand and silt, well graded			SL	50		4/18	22%		SPT #9 70 to 71.5' SPT full of muddy sand
75												

08-29-2005 WATER_PR\PROJECTS\Bob A\Well Logs\Nilan East Dam\Nilan East DH-9 Soil.bor

WELL COMPLETION LOG NO: DH9

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: B61
DATE STARTED	: 11/27/2000	DRILLING METHOD	: Auger
DATE COMPLETED	: 11/29/2000	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Drilling	LOGGED BY	: Kevin Smith
DRILLER	:	APPROVED BY	: Brian Grant

Depth In Feet	Surf. Elev. 4432.7
0	4432
5	4427
10	4422
15	4417
20	4412
25	4407
30	4402
35	4397
40	4392
45	4387
50	4382
55	4377
60	4372
65	4367
70	4362
75	

Well Construction Information

WELL CONSTRUCTION

Date Compl. : 11/29/2000
Hole Diameter : 8 inch
DNRC Rep. : Kevin Smith

STANDPIPE

Material : PVC pipe
Diameter : 1 inch
Joints : screwed
Bottom Cap : glued

WELL SCREEN

Material : PVC pipe
Diameter : 1 inch
Length : 5 feet
Opening : .02 inch

SAND PACK

Material : Colorado Silica 10/20

ANNULUS

Material : 3/8 inch Bentonite

WELL COVER

Diameter : 12 inch
Length : 12 inches

NOTES:

Surface Elev: 4432.69 feet

DH9A TOP Elev: 4432.44 feet

DH9B TOP Elev: 4432.30 feet

Top of Cover Elev: 4432.77 feet

Northing:

Easting:

Surveyed By: Jim Beck

Date Surveyed: 6/5/2002

DESCRIPTION

0 to 3 SAND

Sand inside casing
Concrete outside casing

3 to 10 NATIVE BACKFILL
(Clay/Silt, with some pea gravel)

10 to 13 BENTONITE

13 to 23 HOLE CAVED

23 to 30 BENTONITE

30 to 40.8 SAND

31 to 36 SCREEN FOR DH9A

40.8 to 47 BENTONITE

47 to 54 NATIVE BACKFILL
(Clay/Silt, with some pea gravel)

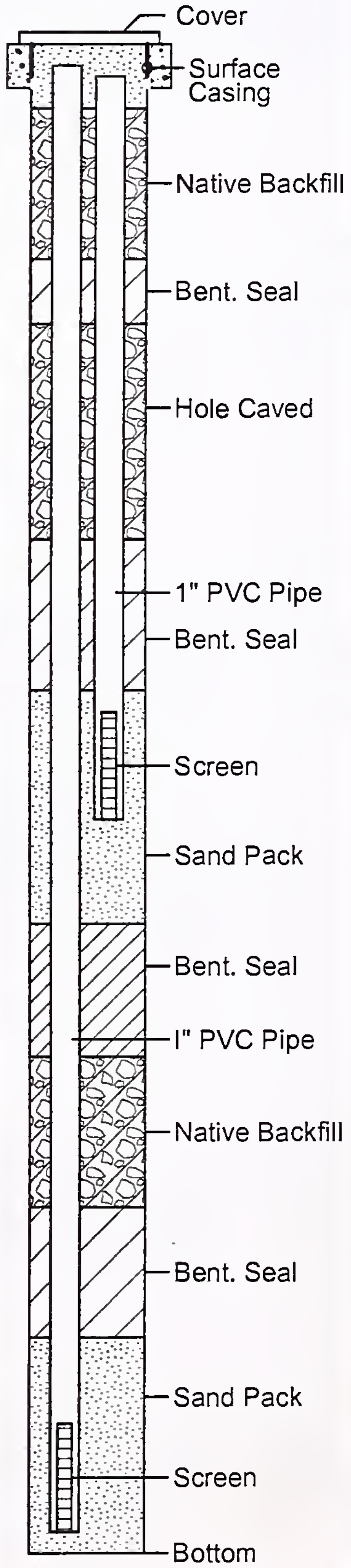
54 to 60 BENTONITE

60 to 70 SAND

64 to 69 SCREEN FOR DH9B

70 BOTTOM OF HOLE

Well1: DH-9A
Well2: DH-9B



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SOIL LOG OF BOREHOLE NO: DH10

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 11/29/2000	DRILLING METHOD	: Auger
DATE COMPLETED	: 11/30/2000	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Driling	LOGGED BY	: Kevin Smith
DRILLER	:	APPROVED BY	: Brian Grant

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4434	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	4434		0 to .5' TOPSOIL with root material									
			.5 to 10' SILTY SAND, gravelly (mostly rounded), brown to red brown, sand fine to medium, dry		░							
5	4429			SM	░							
10	4424	☒	10 to 40' CLAY, gravelly, some sand, brown to reddish brown, stiff to very stiff, slightly moist to moist, some fractured rock pieces up to 1 1/2" diameter		▨	SL	19 26 37	56	10/18	55%		SPT #1 10 to 11.5'
15	4419				▨							
			16 to 18' Large amount of pea gravel in cuttings along with silts and clays	CL	▨							
20	4414	☒	20 to 21.5' 15% gravel		▨	SL	24 21 43	46	9/18	50%		SPT #2 20 to 21.5'
25												

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SOIL LOG OF BOREHOLE NO: DH10

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: MB61
DATE STARTED	: 11/29/2000	DRILLING METHOD	: Auger
DATE COMPLETED	: 11/30/2000	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Driling	LOGGED BY	: Kevin Smith
DRILLER	:	APPROVED BY	: Brian Grant

SAMPLER TYPE

SS	Split spoon
SL	Split Spoon Brass Liners
ST	Shelby Tube

Depth in Feet	Surf. Elev. 4434	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
25	4409				▨							
30	4404	☒	30 to 31.5' moist		▨	SL	14 20 50		9/18	50%		SPT #3 30 to 31.5'
				CL	▨							
35	4399				▨							
40	4394	☒	40' BOTTOM OF HOLE higher sand content, moist to almost very moist			SL	30 50 R		11/18	61%		SPT #4 40 to 41.5'
45	4389											
50												

WELL COMPLETION LOG NO: DH10

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan East Dam	DRILL RIG	: B61
DATE STARTED	: 11/29/2000	DRILLING METHOD	: Auger
DATE COMPLETED	: 11/30/2000	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: O'Keefe Drilling	LOGGED BY	: Kevin Smith
DRILLER	:	APPROVED BY	: Brian Grant

Depth In Feet	Surf. Elev. 4434.6
0	4434
5	4429
10	4424
15	4419
20	4414
25	4409
30	4404
35	4399
40	4394
45	

Well Construction Information

WELL CONSTRUCTION
Date Compl. : 11/7/1999
Hole Diameter : 8 inch
DNRC Rep. : Bob Arrington

STANDPIPE
Material : PVC pipe
Diameter : 1 inch
Joints : screwed
Bottom Cap : glued

WELL SCREEN
Material : PVC pipe
Diameter : 1 inch
Length : 5 feet
Opening : .02 inch

SAND PACK
Material : Colorado Silica 10/20

ANNULUS
Material : 3/8 inch Bentonite

WELL COVER
Diameter : 12 inch
Length : 12 inches

NOTES:

Surface Elev: 4434.58 feet

DH10 TOP Elev: 4434.39 feet

Top of Cover Elev: 4434.69 feet

Northing:

Easting:

Surveyed By: Jim Beck

Date Surveyed: 6/5/2002

DESCRIPTION

0 to 6 SAND

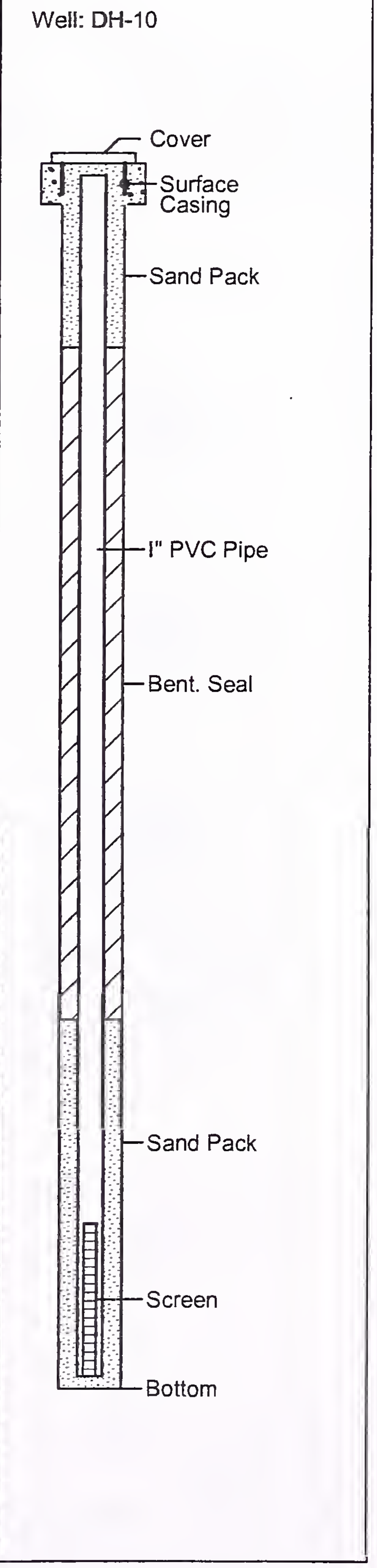
Sand inside casing.
Concrete outside casing.

6 to 28 BENTONITE

28 to 40 SAND PACK

34.6 to 39.6 SCREEN FOR DH10

40 BOTTOM OF HOLE



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MONTANA DNRC

SOIL LOG OF BOREHOLE NO: DH1

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : NILAN NORTH DAM
DATE STARTED : 11/5/1999
DATE COMPLETED : 11/6/1999
DRILL COMPANY : Bush Drilling
DRILLER :
DRILL RIG : B-53 Track
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Jim Robinson
APPROVED BY : Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4451.3	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
0	4451		0 to 20' LEAN CLAY with sand, brown, damp, stiff		▨							
5	4446	☒				SS	6 9 8	23	9/18	50%		
10	4441	☒		CL		SL	9 21 26	42	11.7/18	65%		10 to 11.5' m = 22.3% % Finer #200 = 77% LL=37% PL=16% PI=21% DS: Phi = 27.2, C = 2.97 Dry Unit Weight = 99.4 pcf Moist Unit Weight = 117.2 pcf
15	4436	☒				SS	6 12 15	24	6.3/18	35%		
20	4431	☒	20 to 32.5' SANDY LEAN CLAY, some gravel, brown, damp, stiff		▨	SL	12 20 32	37				20.5 to 21' m = 7.27% % Finer #200 = 56% % Sand = 44% Dry Unit Weight = 115 pcf Moist Unit Weight = 123.2 pcf Double Hyd--% Dispersion = 41.4%
25	4426	☒		CL		SS	8 15 17	25	10.8/18	60%		
30												

Hollow Stem Auger 4 1/2" ID
Core Barrel HQ3
Hammer 140 lbs 30' drop free-fall hoist
Standard Spoon 2.0" OD 1.5" ID
Brass Liner Spoon 2.5" OD 2.0" ID

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SOIL LOG OF BOREHOLE NO: DH1

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : NILAN NORTH DAM
DATE STARTED : 11/5/1999
DATE COMPLETED : 11/6/1999
DRILL COMPANY : Bush Drilling
DRILLER :

DRILL RIG : B-53 Track
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Jim Robinson
APPROVED BY : Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4451.3	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	REMARKS
30	4421	☒		CL		SL	12 23 29	34	10.8/18	60%		
		☒	32.5 to 40' CLAYEY SAND, brown to dark brown, moist, medium stiff	SC		SS	8 12 15	19	9/18	50%		
35	4416	☒	At 32.5' foundation contact, dark brown, roots and grass			SS	9 6 3	6	11.7/18	65%		35 to 36' m = 17.9% % Finer #200 = 44% % Sand = 55% LL=25% PL=14% PI=11%
40	4411	☒	40 to 45' SANDY LEAN CLAY, light brown to brown, wet (saturated), very soft	CL		SS	2 3 3	4	12.6/18	70%		40 to 41' m = 21.1% % Finer #200 = 55% LL=26% PL=14% PI=12%
45	4406	☒	45 to 55' CLAYEY SAND with gravel, brown, wet	SC		ST			15.6/24	65%		45 to 47' m = 19% % Finer #200 = 47% % Sand = 36% LL=30% PL=13% PI=17% e (void ratio) = 0.44 Dry Unit Weight = 117 pcf Moist Unit Weight = 139.6 pcf Triaxial CU w/pore pressure Phi = 16.1 C=288 psf Phi' = 31.9 C'=269 psf
50	4401	☒	At 50 to 55' interbedded shale layers with clay, sand			SS	4 9 21	17	5.4/18	30%		
55	4396	☒	55 to 56.5' SHALE, black, claystone with gypsum lens	SH		SS	13 21 50					Refer to digital photos in project file.
			56.5' BOTTOM OF HOLE									
60												

Hollow Stem Auger 4 1/2" ID
Core Barrel HQ3
Hammer 140 lbs 30' drop free-fall hoist
Standard Spoon 2.0" OD 1.5" ID
Brass Liner Spoon 2.5" OD 2.0" ID

08-29-2005 ATER_PR\PROJECTS\Bob A\Well Logs\Nilan North Dam\Nilan North DH-1 Soil.bor

WELL COMPLETION LOG NO: DH1

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan North Dam	DRILL RIG	: B-53 Track
DATE STARTED	: 11/5/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 11/6/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Jim Robinson
DRILLER	:	APPROVED BY	: Kevin Smith

Depth In Feet	Surf. Elev. 4451.3
0	4451
5	4446
10	4441
15	4436
20	4431
25	4426
30	4421
35	4416
40	4411
45	4406
50	4401
55	4396
60	

Well Construction Information

WELL CONSTRUCTION

Date Compl. : 11/6/1999
Hole Diameter : 8 inch
DNRC Rep. : Jay Johnson

STANDPIPE

Material : PVC pipe
Diameter : 1 inch
Joints : screwed
Bottom Cap : glued

WELL SCREEN

Material : PVC pipe
Diameter : 1 inch
Length : 5 feet
Opening : .02 inch

SAND PACK

Material : Colorado Silica 10/20

ANNULUS

Material : 3/8 inch Bentonite

WELL COVER

Diameter : 5 inch
Length : 5 feet

NOTES:

Surface Elev: 4451.3 feet (estimate)

DH1A TOP Elev: 4451.55 feet

DH1B TOP Elev: 4451.7 feet

Top of Cover Elev: 4451.8 feet (estimate)

Northing: 12732.41

Easting: 2214.60

Surveyed By: Mike Lesnik

Date Surveyed: 11/15/1999

DESCRIPTION

0 to 5 SAND

5 to 17 BENTONITE

17 to 27 SAND

21 to 26 SCREEN FOR DH1B

27 to 39 BENTONITE

32.5 embankment/foundation contact

39 to 50 SAND

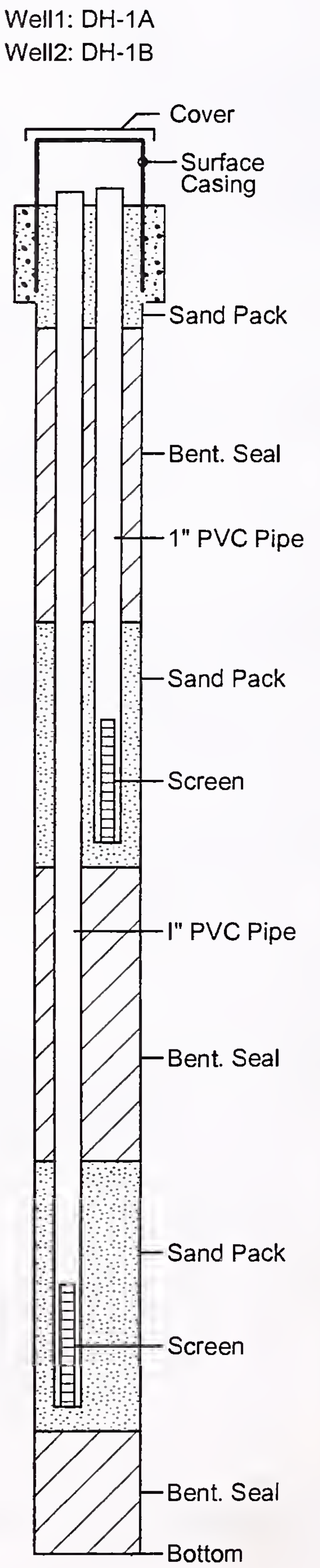
44 to 49 SCREEN FOR DH1A

48 estimated bedrock contact

50 to 56.5 BENTONITE

56.5 BOTTOM OF HOLE

Depth In Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60



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SOIL LOG OF BOREHOLE NO: DH2

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : NILAN NORTH DAM
DATE STARTED : 11/5/1999
DATE COMPLETED : 11/6/1999
DRILL COMPANY : Bush Drilling
DRILLER :

DRILL RIG : Strata Star 15
DRILLING METHOD : Auger/Core
SAMPLING METHOD : Split Spoon
LOGGED BY : Johnson / Arrington
APPROVED BY : Kevin Smith

SAMPLER TYPE
SS Split Spoon
SL Split Spoon Brass Liners
ST Shelby Tube
CT Continuous Sample

Depth in Feet	Surf. Elev. 4451.6	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Drlven	% Recovery	Pocket Penetrometer (tons/square foot)	
0	4451		0 to 43.5' LEAN CLAY with sand, few small gravels, brown to yellowish orange brown, slightly moist, medium stiff to stiff, trace carbonaceous materials	CL	▨							
5	4446	☒				SS	5 7 7 7	22	21.6/24	90%		
10	4441	☒	At 10' yellowish orange, dry, medium stiff, trace carbonaceous material			SL	7 13 18	32	18/18	100%		10 to 11.5' % Finer #200 = 84% LL=37% PL=16% PI=21%
15	4436	☒				SS	14 18 20	39	0/18	0%		
20	4431	☒	At 20' yellowish orange, slightly moist, few gravels At 21' olive gray			SL	4 7 28	28	16.8/18	93%		20 to 21.5' % Finer #200 = 74% % Sand = 22% m = 11.2% LL=32% PL=15% PI=17%
25	4426	☒				SS	5 7 10	11	12/18	66%		
30	4421	☒	At 30' sandy, yellowiish orange to olive gray, some gravels, slightly moist			SL	28 9 12	15	16/18	87%		30.5 to 31.5' m = 10.2% % Finer #200 = 54% Dry Unit Weight = 108.0 pcf Moist Unit weight = 119.0 pcf
35												

Hollow Stem Auger 4 1/2" ID
Core Barrel HQ3
Hammer 140 lbs 30" drop hydraulic
Standard Spoon 2.0" OD 1.5" ID
Brass Liner Spoon 2.5" OD 2.0" ID

Core descriptions reviewed and relogged by Craig Stiles.

08-29-2005 ATER_PR\PROJECTS\Bob A\Well Logs\Nilan North Dam\Nilan North DH-2 Soil.bor

SOIL LOG OF BOREHOLE NO: DH2

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: NILAN NORTH DAM	DRILL RIG	: Strata Star 15
DATE STARTED	: 11/5/1999	DRILLING METHOD	: Auger/Core
DATE COMPLETED	: 11/6/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Johnson / Arrington
DRILLER	:	APPROVED BY	: Kevin Smith

SAMPLER TYPE
SS Split Spoon
SL Split Spoon Brass Liners
ST Shelby Tube
CT Continuous Sample

Depth in Feet	Surf. Elev. 4451.6	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	
35	4416	☒	At 35' yelloish orange, moist, medium stiff, few gravels, trace carboneceous material	CL		SS	5 7 8	12	16/18	87%		
		☒				SS	5 8 11		16/18	87%		40 to 41' m = 22.2% % Finer #200 = 94% LL=42% PL=18% PI=24%
40	4411	☒	40' water inside augers			CT					1.9	
		☒				CT					4.3	43.5' Estimated Bedrock Contact
		☒				CT					4.5	
		☒	43.5 to 45' SHALE, black to brown, carbonaceous, with layer of fat clay (ELASTIC SILT, whitish brown to brown)	SH		CT					3.1	43.5 to 44.5' % Finer #200 = 88% LL=62% PL=35% PI=27%
45	4406	☒				CT					0.75	
		☒	45 to 50' MUDSTONE with shale and sandstone fragments, olive gray	MS		CT					4.5	45.5' Stop augering, begin coring 45.5 to 50.5' Cored 5.0' Recovery 100% RQD = 65%
50	4401		50 to 51.5' SANDSTONE, calcareous, light to dark gray, some fractures	SS								50.5 to 60.5' Cored 10' Recovered 100% RQD = 80%
			51.5 to 54' SHALE, carbonaceous, calcareous, black, shell fragments	SH								
55	4396		54 to 65' SANDSTONE, calcareous (sandy limestone), transitional to medium gray, fine grained to medium grained, shell fragments	SS								
60	4391		60.5 to 61' mudstone/shale layer									60.5 to 65.5' Cored 5' Recovery 100% RQD = 73% Refer to digital photos in project file.
65	4386		65' BOTTOM OF HOLE									
70												

Hollow Stem Auger 4 1/2" ID
Core Barrel HQ3
Hammer 140 lbs 30" drop hydraulic
Standard Spoon 2.0" OD 1.5" ID
Brass Liner Spoon 2.5" OD 2.0" ID

Core descriptions reviewed and relogged by Craig Stiles.

WELL COMPLETION LOG NO: DH2

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan North Dam	DRILL RIG	: Strata Star 15
DATE STARTED	: 11/5/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/6/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Johnson/Arrington
DRILLER	:	APPROVED BY	: Kevin Smith

Depth In Feet	Surf. Elev. 4451.6
0	4451
5	4446
10	4441
15	4436
20	4431
25	4426
30	4421
35	4416
40	4411
45	4406
50	4401
55	4396
60	4391
65	4386
70	

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 11/6/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Bob Arrington

STANDPIPE

Material	: PVC pipe
Diameter	: 1 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 1 inch
Length	: 5 feet
Opening	: .02 inch

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 5 inch
Length	: 5 feet

NOTES:

Surface Elev: 4451.6 feet (estimate)

DH2A TOP Elev: 4451.75 feet

DH2B TOP Elev: 4451.98 feet

Top of Cover Elev: 4452.1 feet (estimate)

Northing: 12687.57

Easting: 2290.92

Surveyed By: Mike Lesnik

Date Surveyed: 11/15/1999

DESCRIPTION

0 to 5 SAND

5 to 30 BENTONITE

30 to 41 SAND

35 to 40 SCREEN FOR DH2B

41 to 51 BENTONITE

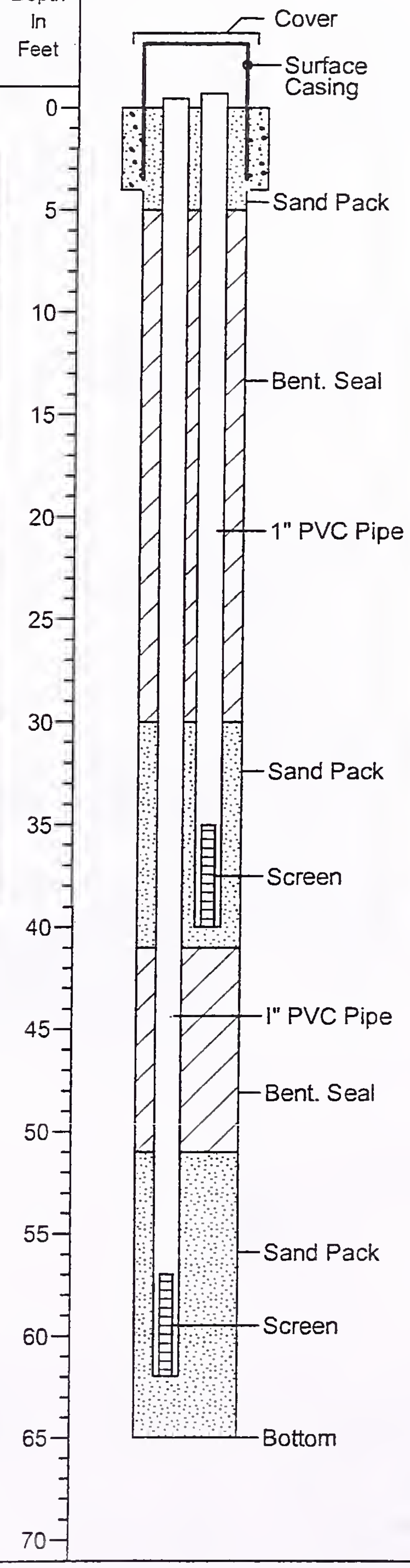
41 estimated embankment foundation contact
45.5 bedrock contact

51 to 65 SAND

57 to 62 SCREEN FOR DH2A

65 BOTTOM OF HOLE

Well1: DH-2A
Well2: DH-2B



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SOIL LOG OF BOREHOLE NO: DH3

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MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: NILAN NORTH DAM	DRILL RIG	: B-53 Track
DATE STARTED	: 11/6/1999	DRILLING METHOD	: Auger/Core
DATE COMPLETED	: 11/7/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Bob Arrington
DRILLER	:	APPROVED BY	: Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4452.0	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	
0	4452		0 to 19' LEAN CLAY with sand, brown to dark brown, some gravel pebbles and rock pieces, firm, dry	CL	▨							
5	4447	☒	At 5' greenish gray, firm			SS	8 13 14	37	12/24	56%		5 to 6.5' % Finer #200 = 83% m = 19% LL=47% PL=20% PI=27%
10	4442	☒	At 10' yellowish brown, firm			SS	7 10 11	20	13.8/18	76%		
		☒				SS	9 15 16	30	13.2/18	73%		
15	4437	☒	At 14' several large pieces of gray sandstone and red sandstone, stiff			SS	9 15 14	27	13.2/18	73%		
		☒	At 18' greenish to olive gray, dry, very stiff to hard			SS	15 25 50	33	15.6/18	86%		17.5 to 19' m = 13% % Finer #200 = 81% % Sand = 18% LL=46% PL=23% PI=23%
20	4432		19 to 37.4' SANDSTONE, interbedded with shale and siltstone layers, light brown to dark gray, numerous fractures, calcareous, shell fragments	SS	▤							19' Estimated bedrock contact
25	4427	☒				SL	50+		1.5/6	25%		
												28.5' Stopped augering, begin coring 28.5 to 35.5' Cored 7' Recovery 7' 100% RQD = 58%
30												

Hollow Stem Auger 4 1/2" ID
Core Barrel HQ3
Hammer 140 lbs 30" drop free-fall hoist
Standard Spoon 2.0" OD 1.5" ID
Brass Liner Spoon 2.5" OD 2.0" ID

Core description reviewed and relogged by Craig Stiles.

08-29-2005 G:\WATER_PR\PROJECTS\Bob A\Well Logs\Nilan North Dam\Nilan North DH-3 Soil.bor

SOIL LOG OF BOREHOLE NO: DH3

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: NILAN NORTH DAM	DRILL RIG	: B-53 Track
DATE STARTED	: 11/6/1999	DRILLING METHOD	: Auger/Core
DATE COMPLETED	: 11/7/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Bob Arrington
DRILLER	:	APPROVED BY	: Kevin Smith

SAMPLER TYPE

SS Split spoon

SL Split Spoon Brass Liners

ST Shelby Tube

Depth in Feet	Surf. Elev. 4452.0	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	
30	4422			SS								
35	4417											35.5 to 45.5' Cored 10' Recovery 10' 100% RQD = 65%
			37.4 to 38.8' SHALE, calcareous, light gray-brown, strongly fractured	SH								
40	4412		38.8 to 44' SANDSTONE, calcareous, fine grained, light gray, shell fragments	SS								
45	4407		44 to 46' SHALE, carbonaceous, calcite-rich, with black siltstone, with bedding plane fault gouge	SH								45.5 to 50.5' Cored 5' Recovery 5' 100% RQD = 78%
			46 to 50.5' SANDSTONE, calcareous, fine grained, medium gray, shell fragments	SS								Refer to digital photos in project file.
50	4402											
			50.5' BOTTOM OF HOLE									
55	4397											
60												

Hollow Stem Auger 4 1/2" ID
Core Barrel HQ3
Hammer 140 lbs 30" drop free-fall hoist
Standard Spoon 2.0" OD 1.5" ID
Brass Liner Spoon 2.5" OD 2.0" ID

Core description reviewed and relogged by Craig Stiles.

08-29-2005 WATER_PR\PROJECTS\Bob A\Well Logs\Nilan North Dam\Nilan North DH-3 Soil.bor

MONTANA DNRC

WELL COMPLETION LOG NO: DH3A

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan North	DRILL RIG	: B53 Track
DATE STARTED	: 11/6/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/7/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Bob Arrington
DRILLER	:	APPROVED BY	: Kevin Smith

Depth In Feet	Surf. Elev. 4452.0
0	4452
5	4447
10	4442
15	4437
20	4432
25	4427
30	4422
35	4417
40	4412
45	4407
50	4402
55	

Well Construction Information

WELL CONSTRUCTION

Date Compl.	: 11/7/1999
Hole Diameter	: 8 inch
DNRC Rep.	: Bob Arrington

STANDPIPE

Material	: PVC pipe
Diameter	: 1 inch
Joints	: screwed
Bottom Cap	: glued

WELL SCREEN

Material	: PVC pipe
Diameter	: 1 inch
Length	: 5 feet
Opening	: .02 inch

SAND PACK

Material	: Colorado Silica 10/20

ANNULUS

Material	: 3/8 inch Bentonite

WELL COVER

Diameter	: 5 inch
Length	: 5 feet

NOTES:

Surface Elev: 4452.0 feet (estimate)

DH3A TOP Elev: 4452.31 feet

Top of Cover Elev: 4452.4 feet (estimate)

Northing: 12660.32

Easting: 2389.26

Surveyed By: Mike Lesnik

Date Surveyed: 11/15/1999

DESCRIPTION

0 to 5 SAND

5 to 39 BENTONITE

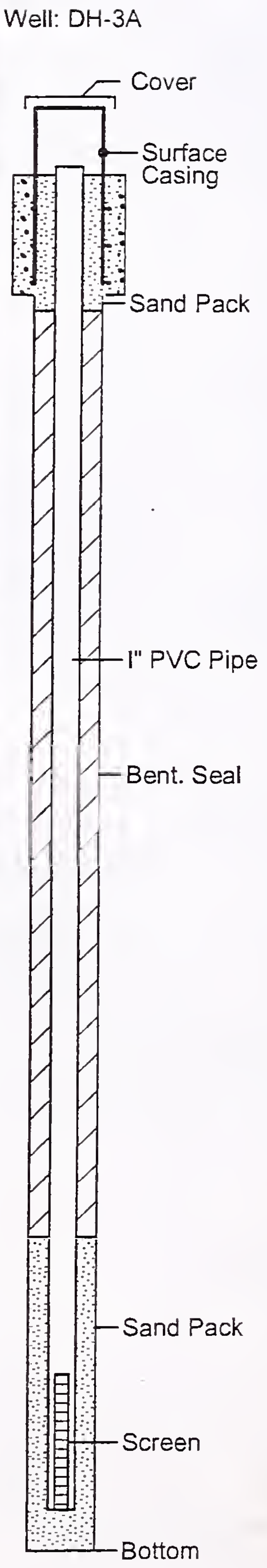
25 Bedrock Contact

Could not get sand to settle in location of planned DH3B screen location (24 to 29 feet). Decided to drill a new hole for DH3B.

39 to 50.5 SAND PACK

44 to 49 SCREEN FOR DH3A

50.5 BOTTOM OF HOLE



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WELL COMPLETION LOG NO: DH3B

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan North	DRILL RIG	: B53 Track
DATE STARTED	: 11/7/1999	DRILLING METHOD	: auger
DATE COMPLETED	: 11/7/1999	SAMPLING METHOD	: none
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Bob Arrington
DRILLER	:	APPROVED BY	: Kevin Smith

Depth In Feet	Surf. Elev. 4452.2	DESCRIPTION
0	4452	0 to 5 SAND
5	4447	5 to 16 BENTONITE
10	4442	
15	4437	16 to 25 SAND 18 to 23 SCREEN FOR DH3B
20	4432	
25	4427	25 BOTTOM OF HOLE
30		

Well Construction Information

WELL CONSTRUCTION
Date Compl. : 11/7/1999
Hole Diameter : 8 inch
DNRC Rep. : Bob Arrington

STANDPIPE
Material : PVC pipe
Diameter : 1 inch
Joints : screwed
Bottom Cap : glued

WELL SCREEN
Material : PVC pipe
Diameter : 1 inch
Length : 5 feet
Opening : .02 inch

SAND PACK
Material : Colorado Silica 10/20

ANNULUS
Material : 3/8 inch Bentonite

WELL COVER
Diameter : 5 inch
Length : 5 feet

NOTES:

Surface Elev: 4452.2 feet (estimate)

DH3B TOP Elev: 4452.58 feet

Top of Cover Elev: 4452.7 feet (estimate)

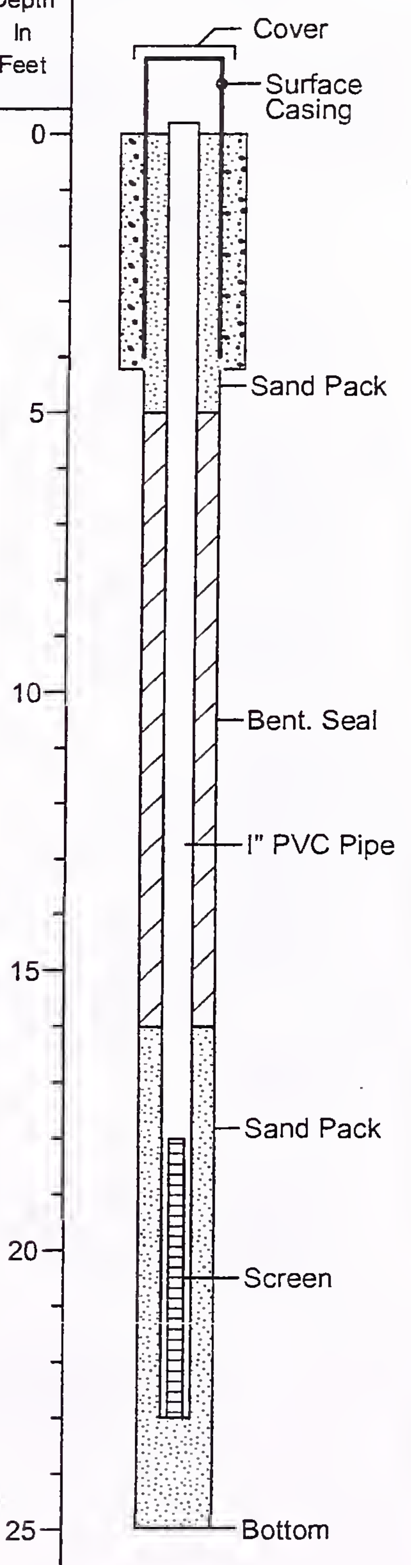
Northing: 12660.20

Easting: 2383.36

Surveyed By: Mike Lesnik

Date Surveyed: 11/15/1999

Well: DH-3B



08-29-2005 ATER_PR\PROJECTS\Bob A\Well Logs\Nilan North Dam\Nilan North DH-3B WC.bor

SOIL LOG OF BOREHOLE NO: DH4

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : NILAN NORTH DAM
DATE STARTED : 11/4/1999
DATE COMPLETED : 11/4/1999
DRILL COMPANY : Bush Drilling
DRILLER :
DRILL RIG : B-53 Track
DRILLING METHOD : Auger/Core
SAMPLING METHOD : Split Spoon
LOGGED BY : Jim robinson
APPROVED BY : Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4422.0	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	
0	4422		0 to 13' LEAN CLAY with sand, brown to dark brown, some gravel, damp, stiff	CL	▨							
		☒				SS	21 17 11	54				
5	4417	☒				SL	11 15 18	41				
		☒				SS						
10	4412	☒				SL	12 17 14	28				10.5 to 11' % Finer #200 = 70% m = 15% LL=40% PL=16% PI=24% Dry Unit Weight = 110.7 pcf Moist Unit Weight = 127.3 pcf
		☒	13 to 20' FAT CLAY with sand, brown to dark brown. damp, firm to soft	CH	▨	SS	4 6 7	13	1.8/18	10%		
15	4407	☒				SL	9 27 24	42	0/18	0%		
		☒	at 17.5 to 19' dark brown, wet lens, gypsum fragments, orange oxide zone			SS	8 10 38	40				18 to 18.5' % Finer #200 = 78% % Sand = 11% LL=54% PL=26% PI=28%
20	4402		20 to 25' SHALE/ SILTSTONE, dark gray, numerous fractures, calcareous, shell fragments	SH	▤							20' Bedrock contact - weathered shale 20 to 23' Cored 3' Recovery 85% RQD* = 47%
25												

*NOTE: Low RQDs may be due to transport and length of time in boxes.
Hollow Stem Auger 4 1/2" ID Core Barrel HQ3
Hammer 140 lbs 30" drop free-fall hoist
Standard Spoon 2.0" OD 1.5" ID
Brass Liner Spoon 2.5" OD 2.0" ID

Core descriptions reviewed and relogged by Craig Stiles.

SOIL LOG OF BOREHOLE NO: DH4

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: NILAN NORTH DAM	DRILL RIG	: B-53 Track
DATE STARTED	: 11/4/1999	DRILLING METHOD	: Auger/Core
DATE COMPLETED	: 11/4/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Jim robinson
DRILLER	:	APPROVED BY	: Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4422.0	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	
25	4397		25 to 31' SANDSTONE, calcareous, fine grained, medium gray, with abundant shell fragments	SS								23 to 28' Cored 5' Recovery 100% RQD* = 43%
30	4392											28 to 33' Cored 5' Recovery 100% RQD = 60%
			31 to 32.8' SHALE, carbonaceous, calcareous, brown to black, shell fragments	SH								
			32.8 to 38' SANDSTONE/SILTSTONE, calcareous, medium gray, fine grained, shell fragments	SS								33 to 38' Cored 5' Recovery 90% RQD = 57%
35	4387											Refer to digital photos in project' file.
			38' BOTTOM OF HOLE									
40	4382											
45	4377											
50												

*NOTE: Low RQDs may be due to transport and length of time in boxes.

Core descriptions reviewed and relogged by Craig Stiles.

Hollow Stem Auger 4 1/2" ID Core Barrel HQ3
Hammer 140 lbs 30" drop free-fall hoist
Standard Spoon 2.0" OD 1.5" ID
Brass Liner Spoon 2.5" OD 2.0" ID

08-29-2005 ...WATER_PR\PROJECTS\Bob A\Well Logs\Nilan North Dam\Nilan North DH-4 Soil.bor

WELL COMPLETION LOG NO: DH4

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan North Dam
DATE STARTED : 11/4/1999
DATE COMPLETED : 11/4/1999
DRILL COMPANY : Bush Drilling
DRILLER :

DRILL RIG : B-53 Track
DRILLING METHOD : Auger/Coring
SAMPLING METHOD : Split Spoon
LOGGED BY : Jim Robinson
APPROVED BY : Kevin Smith

Depth In Feet	Surf. Elev. 4422
0	4422
5	4417
10	4412
15	4407
20	4402
25	4397
30	4392
35	4387
40	

Well Construction Information

WELL CONSTRUCTION
Date Compl. : 11/4/1999
Hole Diameter : 8 inch
DNRC Rep. : Jim Robinson

STANDPIPE
Material : PVC pipe
Diameter : 1 inch
Joints : screwed
Bottom Cap : glued

WELL SCREEN
Material : PVC pipe
Diameter : 1 inch
Length : 5 feet
Opening : .02 inch

SAND PACK
Material : Colorado Silica 10/20

ANNULUS
Material : 3/8 inch Bentonite

WELL COVER
Diameter : 5 inch
Length : 5 feet

NOTES:

Surface Elev: 4422 feet (estimate)

DH4A TOP Elev: 4422.27 feet

DH4B TOP Elev: 4422.89 feet

Top of Cover Elev: 4423.4 feet (estimate)

Northing: 12855.20

Easting: 2119.09

Surveyed By: Mike Lesnik

Date Surveyed: 11/15/1999

DESCRIPTION

0 to 5 SAND

5 to 11 BENTONITE

11 to 20 SAND

13 to 18 SCREEN FOR DH4B

20 to 24 BENTONITE

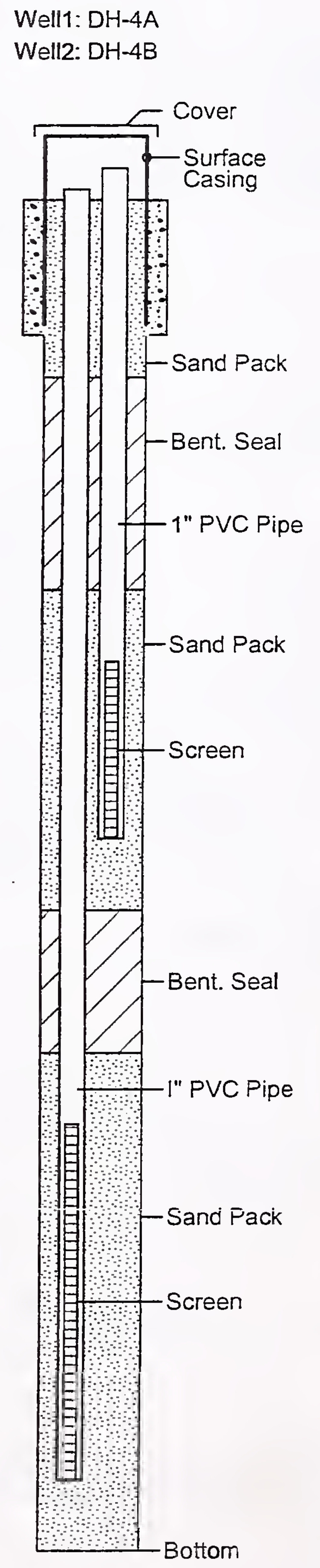
20 Bedrock Contact

24 to 38 SAND

26 to 36 SCREEN FOR DH4A

38 BOTTOM OF HOLE

Depth In Feet: 0, 5, 10, 15, 20, 25, 30, 35, 40



SOIL LOG OF BOREHOLE NO: DH5

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : NILAN NORTH DAM
DATE STARTED : 11/2/1999
DATE COMPLETED : 11/3/1999
DRILL COMPANY : Bush Drilling
DRILLER :

DRILL RIG : B-53 Track
DRILLING METHOD : Auger/Core
SAMPLING METHOD : Split Spoon
LOGGED BY : Kirk Warren
APPROVED BY : Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4413.0	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	
0	4413		0 to 10' LEAN CLAY with sand, brown to dark brown, moist, soft		▨							3 to 3.5' PH = 7.7 soluble sulfate = 3430.1mg/kg
5	4408	☒		CL	▨	SL	2 1 5	7	18/18	100%		5 to 5.5' % Finer #200 = 55% m = 30.64% Dry Unit Weight = 90.4 pcf Moist Unit Weight = 118.1 pcf DS: phi = 34.3 C = 0
10	4403	☒	10 to 20' CLAYEY SAND with gravel, brown to grayish brown, soft, moist to wet		▨	SS	13 9 14	22	6/18	33%		11 to 11.5' % Finer #200 = 47% m = 20.3% LL=33% PL=15% PI=18%
15	4398	☒		SC	▨	SL	4 10 14	20	12/18	66%		
20	4393	☒	20 to 26.5' SANDSTONE, calcareous, fine grained, medium gray, shell fragments		▤	SS	23 39 50		6/18	66%		21' Estimated bedrock contact
				SS	▤							20 to 23' Cored 3' Recovery 2.3' 77% RQD = 28%
25					▤							

* NOTE: Low RQDs may be due to transport and length of time in boxes.
Hollw Stem Auger 4 1/2" ID Core Barrel HQ3
Hammer 140 lbs 30" drop free-fall hoist
Standard Spoon 2.0" OD 1.5" ID
Brass Liner Spoon 2.5" OD 2.0" ID

Core descriptions reviewed and relogged by Craig Stiles.

SOIL LOG OF BOREHOLE NO: DH5

(Page 2 of 2)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: NILAN NORTH DAM	DRILL RIG	: B-53 Track
DATE STARTED	: 11/2/1999	DRILLING METHOD	: Auger/Core
DATE COMPLETED	: 11/3/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Kirk Warren
DRILLER	:	APPROVED BY	: Kevin Smith

SAMPLER TYPE
- SS Split spoon
- SL Split Spoon Brass Liners
- ST Shelby Tube

Depth in Feet	Surf. Elev. 4413.0	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	
25	4388			SS								23 to 28' Cored 5' Recovery 5' 100% RQD = 33%
			26.5 to 30' SHALE, carbonaceous, calcareous, dark gray-brown, abundant shell fragments, strongly sheared, fault gouge	SH								28 to 31.5' Cored 3.5' Recovery 2.9' 83% RQD = 32%
30	4383		30 to 40' SANDSTONE, calcareous, fine grained, medium gray, shell fragments									31.5 to 37' Cored 5.5' Recovery 4.9 90% RQD = 47%
35	4378			SS								
												37 to 40' Cored 3' Recovery 3' 100% RQD = 70% Refer to digital phots in project file.
40	4373		40' BOTTOM OF HOLE									
45	4368											
50												

* NOTE: Low RQDs may be due to transport and length of time in boxes.

Core descriptions reviewed and relogged by Craig Stiles.

Hollw Stem Auger 4 1/2" ID Core Barrel HQ3
Hammer 140 lbs 30" drop free-fall hoist
Standard Spoon 2.0" OD 1.5" ID
Brass Liner Spoon 2.5" OD 2.0" ID

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WELL COMPLETION LOG NO: DH5

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MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan North Dam	DRILL RIG	: B-53 Track
DATE STARTED	: 11/2/1999	DRILLING METHOD	: Auger/Coring
DATE COMPLETED	: 11/3/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Kirk Warren
DRILLER	:	APPROVED BY	: Kevin Smith

Depth In Feet	Surf. Elev. 4412.8
0	4412
5	4407
10	4402
15	4397
20	4392
25	4387
30	4382
35	4377
40	4372
45	

Well Construction Information

WELL CONSTRUCTION
Date Compl. : 11/3/1999
Hole Diameter : 8 inch
DNRC Rep. : Kirk Warren

STANDPIPE
Material : PVC pipe
Diameter : 1 inch
Joints : screwed
Bottom Cap : glued

WELL SCREEN
Material : PVC pipe
Diameter : 1 inch
Length : 5 feet
Opening : .02 inch

SAND PACK
Material : Colorado Silica 10/20

ANNULUS
Material : 3/8 inch Bentonite

WELL COVER
Diameter : 5 inch
Length : 5 feet

NOTES:

Surface Elev: 4413.0 feet (estimate)

DH5A TOP Elev: 4413.12 feet

DH5B TOP Elev: 4413.27 feet

Top of Cover Elev: 4413.4 feet (estimate)

Northing: 12815.27

Easting: 2209.79

Surveyed By: Mike Lesnik

Date Surveyed: 11/15/1999

DESCRIPTION

0 to 3 SAND

3 to 5 BENTONITE

5 to 11 SAND

5 to 10 SCREEN FOR DH5B

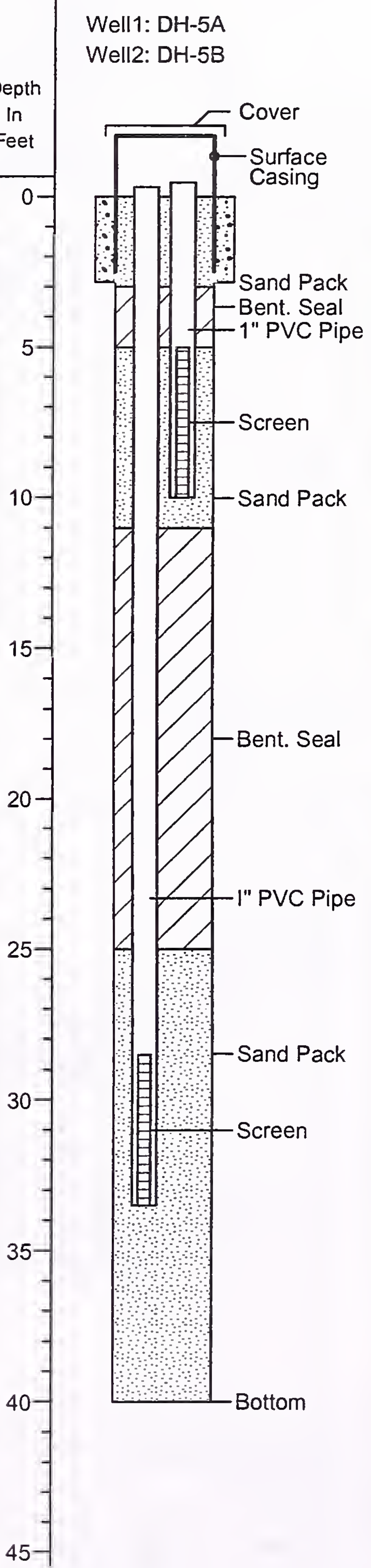
11 to 25 BENTONITE

23 Bedrock Contact

25 to 40 SAND

28.5 to 33.5 SCREEN FOR DH5A

40 BOTTOM OF HOLE



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SOIL LOG OF BOREHOLE NO: DH6

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : NILAN NORTH DAM
DATE STARTED : 11/2/1999
DATE COMPLETED : 11/3/1999
DRILL COMPANY : Bush Drilling
DRILLER :

DRILL RIG : D366
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Arrington/Johnson
APPROVED BY : Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4418.3	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd / Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	
0	4418		0 to 16' LEAN CLAY, light brown to brown, slightly moist to dry, stiff, trace of cabonaceous material	CL	▨							
5	4413				▨							
10	4408	☒			▨	SS	6 11 15	26	15.6/18	87%		10 to 11.5' % Finer #200 = 91% m = 18.8% LL=45% PL=20% PI=25%
15	4403	☒			▨	SL	13 32 50+		13.8/16	86%		16' Estimated bedrock contact
			16 to 20' SANDSTONE/SILTSTONE, fine grained, greenish gray, stiff, slightly moist, carboneceous material, shell fragments at 18 to 18.5' appear to drill through water bearing sand layer	SS	▤							
20	4398	☒	20 to 29' SANDSTONE, light gray, fine grained, moist, stiff, micaceous, trace clay	SS	▤	SS	43 50+		8/8	100%		
25												

Hollow Stem Auger 4 1/2" ID
Core Barrel HQ3
Hammer 140 lbs 30" drop ~~free-fall~~ hoist
Standard Spoon 2.0" OD 1.5" ID
Brass Liner Spoon 2.5" OD 2.0" ID

Entire hole done using auger, so difficult to tell where bedrock started.

08-29-2005 G:\WATER_PR\PROJECTS\Bob A\Well Logs\Nilan North Dam\Nilan North DH-6 Soil.bor

SOIL LOG OF BOREHOLE NO: DH6

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : NILAN NORTH DAM
DATE STARTED : 11/2/1999
DATE COMPLETED : 11/3/1999
DRILL COMPANY : Bush Drilling
DRILLER :

DRILL RIG : D366
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Arrington/Johnson
APPROVED BY : Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4418.3	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)
25	4393	☒				SL	50+		3.5/3.5	100%	
				SS							
			29 to 38' SHALE/SILTSTONE, dark gray, stiff to hard, dry								
30	4388	☒				SS	7 30 50+		16/16	100%	
				SH							
35	4383	☒				SS	50+		3/3	100%	
			38' BOTTOM OF HOLE								
40	4378										
45	4373										
50											

Hollow Stem Auger 4 1/2" ID
Core Barrel HQ3
Hammer 140 lbs 30" drop free-fall hoist
Standard Spoon 2.0" OD 1.5" ID
Brass Liner Spoon 2.5" OD 2.0" ID

Entire hole done using auger, so difficult to tell where bedrock started.

08-29-2005 WATER_PR\PROJECTS\Bob A\Well Logs\Nilan North Dam\Nilan North DH-6 Soil.bor

MONTANA DNRC

WELL COMPLETION LOG NO: DH6

(Page 1 of 1)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: Nilan North Dam	DRILL RIG	: D366
DATE STARTED	: 11/2/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 11/3/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Arrington/Johnson
DRILLER	:	APPROVED BY	: Kevin Smith

Depth In Feet	Surf. Elev. 4418.3
0	4418
5	4413
10	4408
15	4403
20	4398
25	4393
30	4388
35	4383
40	

Well Construction Information

WELL CONSTRUCTION
Date Compl. : 11/3/1999
Hole Diameter : 8 inch
DNRC Rep. : Jay Johnson

STANDPIPE
Material : PVC pipe
Diameter : 1 inch
Joints : screwed
Bottom Cap : glued

WELL SCREEN
Material : PVC pipe
Diameter : 1 inch
Length : 5 feet
Opening : .02 inch

SAND PACK
Material : Colorado Silica 10/20

ANNULUS
Material : 3/8 inch Bentonite

WELL COVER
Diameter : 5 inch
Length : 5 feet

NOTES:

Surface Elev: 4418.3 feet (estimate)

DH6A TOP Elev: 4418.51 feet

DH6B TOP Elev: 4418.66 feet

Top of Cover Elev: 4418.8 feet (estimate)

Northing: 12771.31

Easting: 2323.90

Surveyed By: Mike Lesnik

Date Surveyed: 11/15/1999

DESCRIPTION

0 to 5 SAND

5 to 11 BENTONITE

11 to 20 SAND

14 to 19 SCREEN FOR DH6B

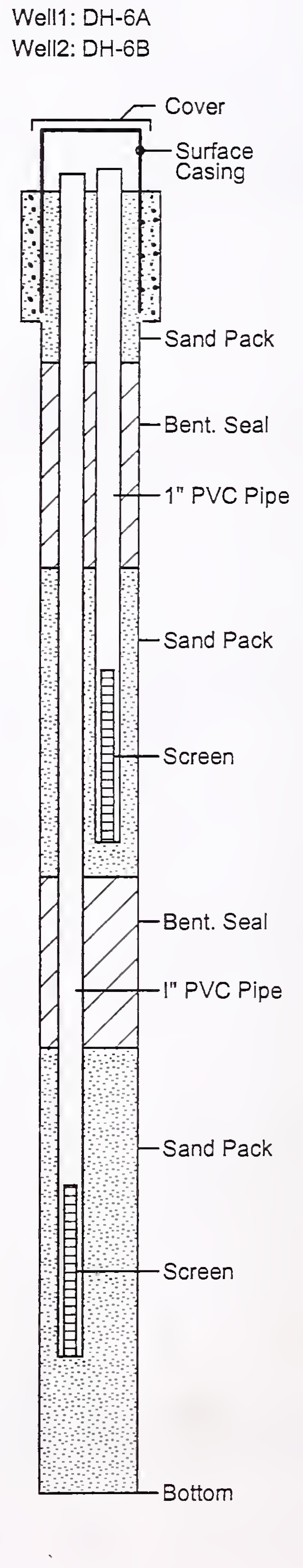
20 to 25 BENTONITE

20 bedrock contact (sandstone)

25 to 38 SAND

29 to 34 SCREEN FOR DH6A

38 BOTTOM OF HOLE



08-29-2005 G:\WATER_PR\PROJECTS\Bob A\Well Logs\Nilan North Dam\Nilan North DH-6 WC.bor

SOIL LOG OF BOREHOLE NO: DH7

(Page 1 of 2)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR	: NILAN NORTH DAM	DRILL RIG	: D366
DATE STARTED	: 11/3/1999	DRILLING METHOD	: Auger
DATE COMPLETED	: 11/5/1999	SAMPLING METHOD	: Split Spoon
DRILL COMPANY	: Bush Drilling	LOGGED BY	: Jay Johnson
DRILLER	:	APPROVED BY	: Kevin Smith

SAMPLER TYPE

SS Split spoon

SL Split Spoon Brass Liners

ST Shelby Tube

Depth in Feet	Surf. Elev. 4441.5	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd / Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)	
0	4441		0 to 13.5' LEAN CLAY with sand, some gravel, yellowish orange, dry, very stiff, slightly cabonaceous	CL								
5	4436	☒				SS	15 20 24	60	12/18	66%		
10	4431	☒				SL	29 50+		9.6/9.6	100%		
			13.5 to 20' SHALE/SILTSTONE, yellowish brown to gray, firm, slightly moist, trace carboneceous material, trace gypsum veins, some shells	SH								13.5' Estimated bedrock contact
15	4426	☒				SS	43 50+		8.4/8.4	100%		
20	4421	☒	20 to 25' SANDSTONE/SILTSTONE, fine grained, yellowish brown, shell fragments	SS		SL	46 50+		7.8/8.4	93%		
25												

Hollow Stem Auger 4 1/2" ID
Core Barrel HQ3
Hammer 140 lbs 30" drop free-fall hoist
Standard Spoon 2.0" OD 1.5" ID
Brass Liner Spoon 2.5" OD 2.0" ID

Entire hole done using auger, so difficult to tell where bedrock started.

08-29-2005 ATER_PR\PROJECTS\Bob A\Well Logs\Nilan North Dam\Nilan North DH-7 Soil.bor

MONTANA DNRC

SOIL LOG OF BOREHOLE NO: DH7

(Page 2 of 2)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : NILAN NORTH DAM
DATE STARTED : 11/3/1999
DATE COMPLETED : 11/5/1999
DRILL COMPANY : Bush Drilling
DRILLER :

DRILL RIG : D366
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Jay Johnson
APPROVED BY : Kevin Smith

SAMPLER TYPE
SS Split spoon
SL Split Spoon Brass Liners
ST Shelby Tube

Depth in Feet	Surf. Elev. 4441.5	Sample Interval	DESCRIPTION	USCS	GRAPHIC	Sampler Type	Blow Count	Adjusted Blow Counts (blows/foot)	Inches Recoverd Inches Driven	% Recovery	Pocket Penetrometer (tons/square foot)
25	4416	☒	25 to 50' SHALE/SILTSTONE, olive gray, dry, firm, some carbonaceous material, breaks into 1-2 mm thick wafers			SS	14 50+		9.6/9.6	100%	
			At 33' hit water								
30	4411	☒	At 30' yellowish gray to dark gray, slightly moist, some carbonaceous material			SL	29 50+		9.6/9.6	100%	
35	4406	☒	At 35' olive gray to light gray, moist, some carbonaceous material			SS	50+		5/5	100%	
				SH							
40	4401	☒	At 40' light gray, moist, firm			SL	50+		3/3	100%	
45	4396	☒	at 45' medium gray, dry, hard			SS	50+		3/3	100%	
50			50' BOTTOM OF HOLE								

Hollow Stem Auger 4 1/2" ID
Core Barrel HQ3
Hammer 140 lbs 30" drop free-fall hoist
Standard Spoon 2.0" OD 1.5" ID
Brass Liner Spoon 2.5" OD 2.0" ID

Entire hole done using auger, so difficult to tell where bedrock started.

08-29-2005 G:\WATER_PR\PROJECTS\Bob A\Well Logs\Nilan North Dam\Nilan North DH-7 Soil.bor

WELL COMPLETION LOG NO: DH7

(Page 1 of 1)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Nilan North Dam
DATE STARTED : 11/3/1999
DATE COMPLETED : 11/5/1999
DRILL COMPANY : Bush Drilling
DRILLER :

DRILL RIG : D-366
DRILLING METHOD : Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Arrington/Johnson
APPROVED BY : Kevin Smith

Depth In Feet	Surf. Elev. 4441.5
0	4441
5	4436
10	4431
15	4426
20	4421
25	4416
30	4411
35	4406
40	4401
45	4396
50	4391
55	

Well Construction Information

WELL CONSTRUCTION
Date Compl. : 11/5/1999
Hole Diameter : 8 inch
DNRC Rep. : Jay Johnson

STANDPIPE
Material : PVC pipe
Diameter : 1 inch
Joints : screwed
Bottom Cap : glued

WELL SCREEN
Material : PVC pipe
Diameter : 1 inch
Length : 5 feet
Opening : .02 inch

SAND PACK
Material : Colorado Silica 10/20

ANNULUS
Material : 3/8 inch Bentonite

WELL COVER
Diameter : 5 inch
Length : 5 feet

NOTES:

Surface Elev: 4441.5 feet (estimate)

DH7A TOP Elev: 4442.18 feet

DH7B TOP Elev: 4442.28 feet

DH7C TOP Elev: 4441.98 feet

Top of Cover Elev: 4442.5 feet (estimate)

Northing: 12717.60

Easting: 2422.08

Surveyed By: Mike Lesnik

Date Surveyed: 11/15/1999

DESCRIPTION

0 to 5 SAND

5 to 15 BENTONITE

15 to 22 SAND
16 to 21 SCREEN FOR DH7C

22 to 27 BENTONITE

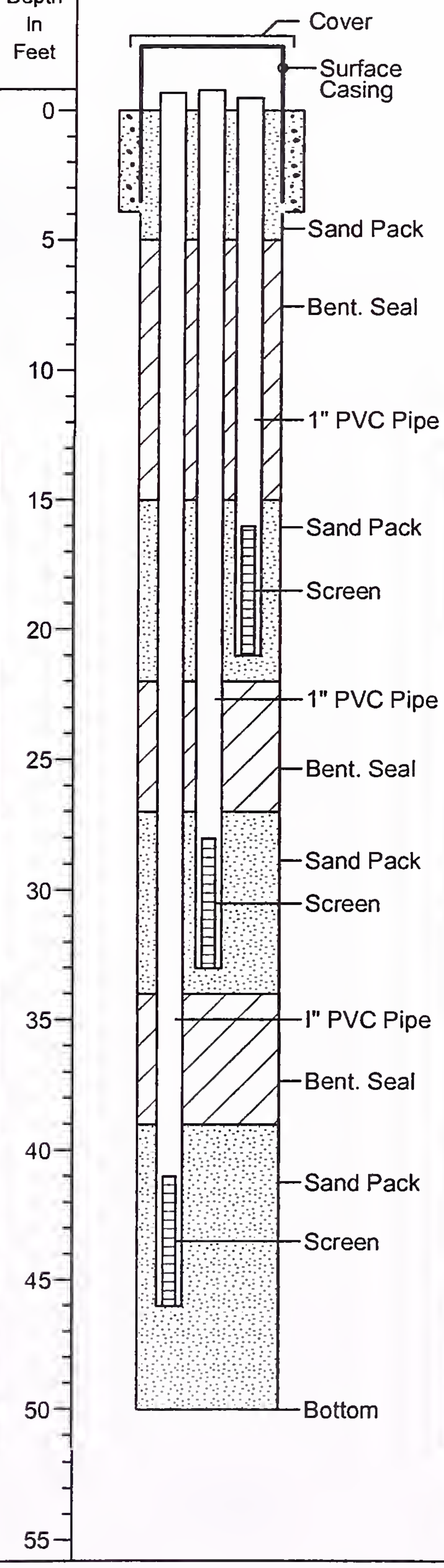
27 to 34 SAND
28 to 33 SCREEN FOR DH7B

34 to 39 BENTONITE

39 to 50 SAND
41 to 46 SCREEN FOR DH7A

50 BOTTOM OF HOLE

Well1: DH-7A
Well2: DH-7B
Well3: DH-7C



08-29-2005 ...ATER_PR\PROJECTS\Bob A\Well Logs\Nilan North Dam\Nilan North DH-7 WC.bor

D66 2005

APPENDIX E

PROJECT DRAWINGS

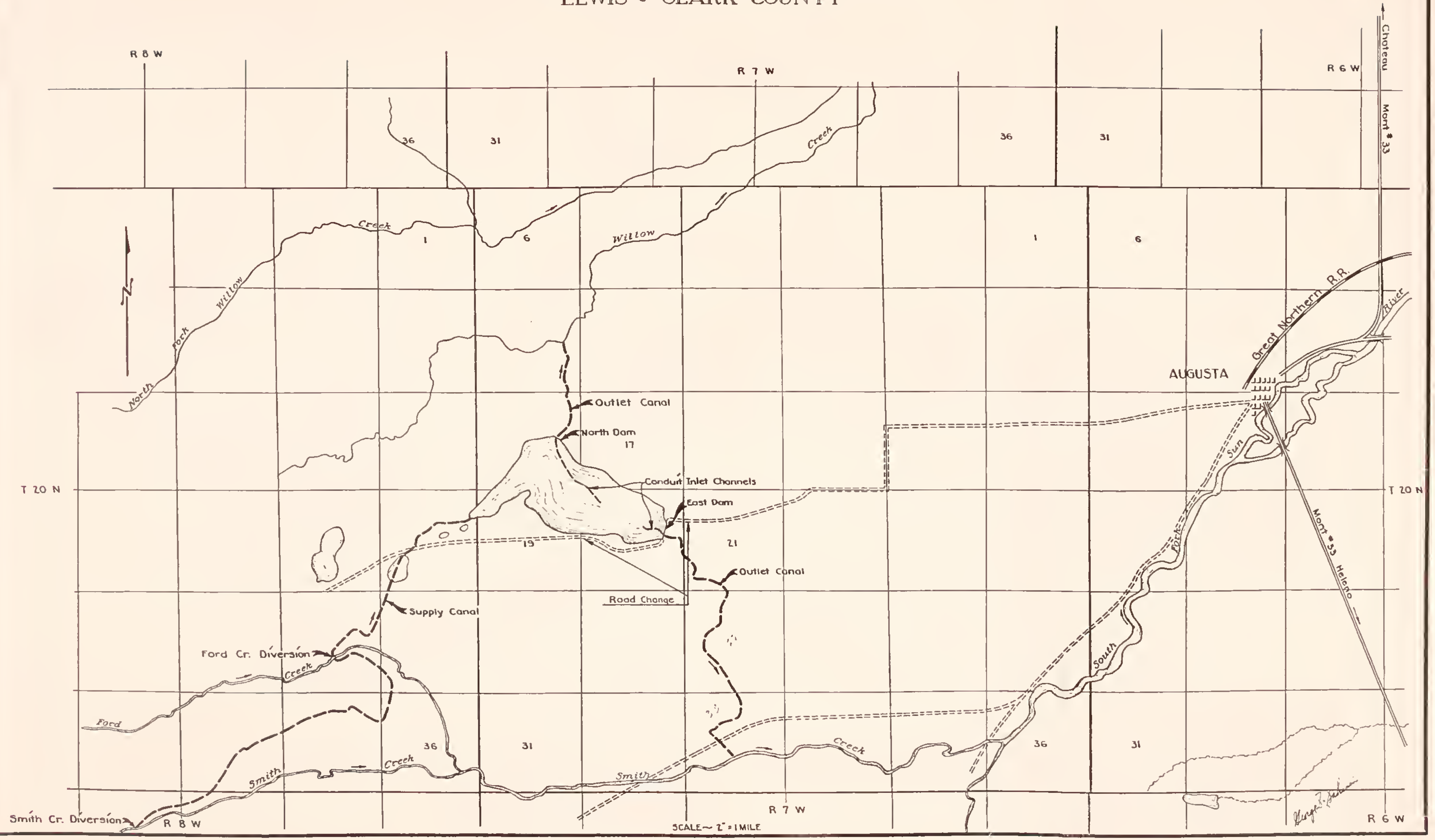
(NOTE: These reduced project drawings are design drawings and not "As Builts". These drawing should be used for reference only. The SWPB has the full size project drawings.)

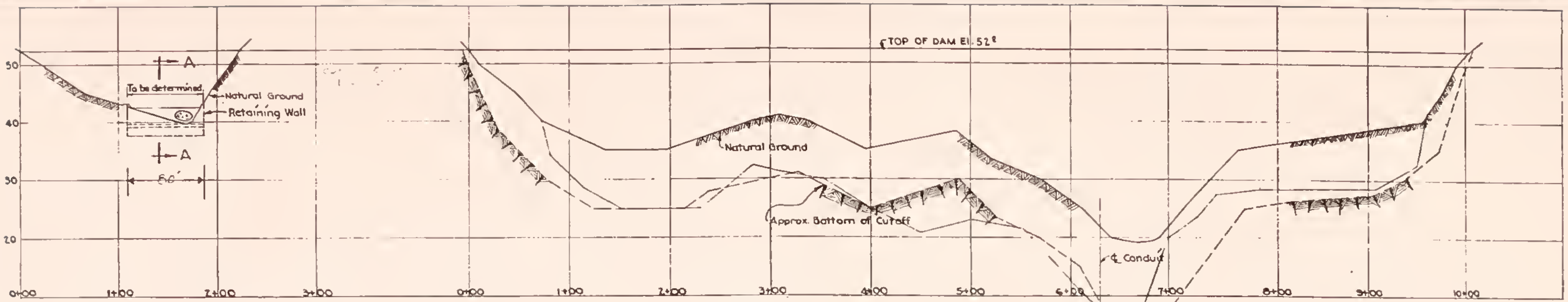
E2 2005

MONTANA WATER CONSERVATION BOARD

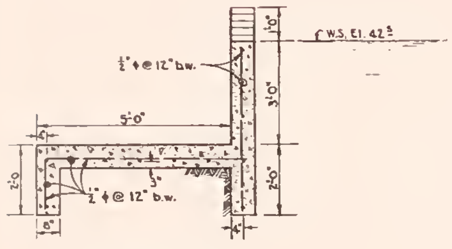
NILAN STORAGE PROJECT

LEWIS & CLARK COUNTY

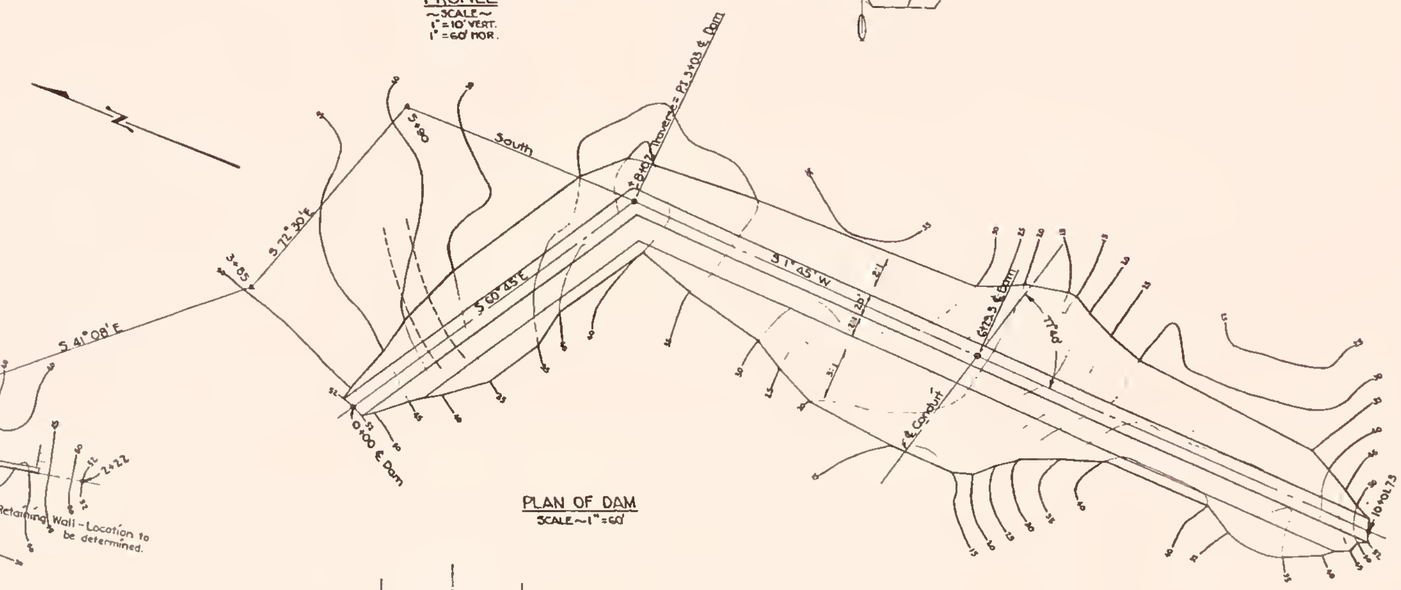




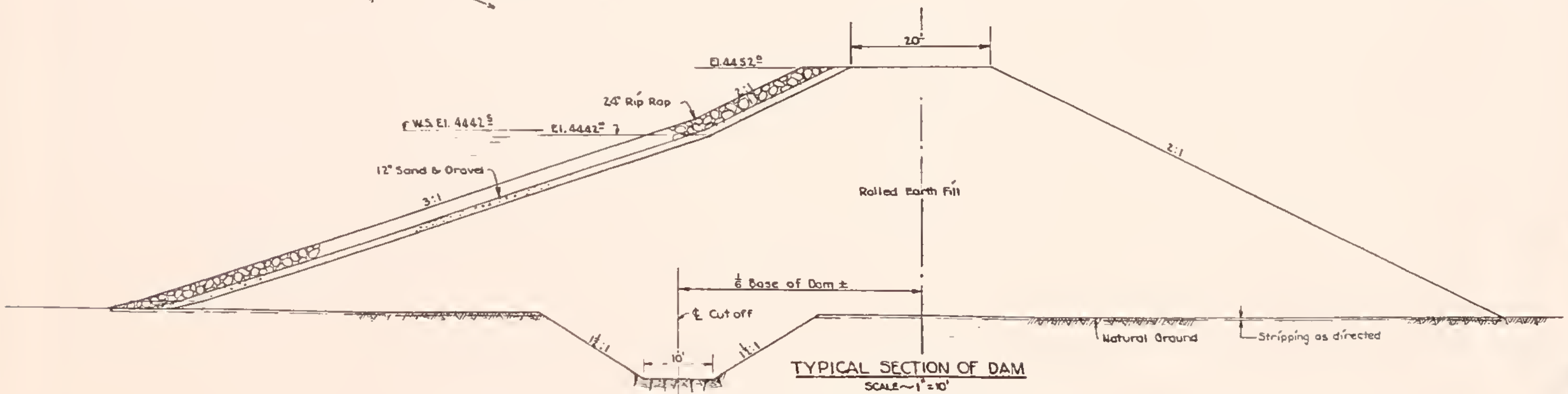
PROFILE
~SCALE~
1" = 10' VERT.
1" = 60' HOR.



RETAINING WALL
SECTION A-A
SCALE~½"=1'-0"

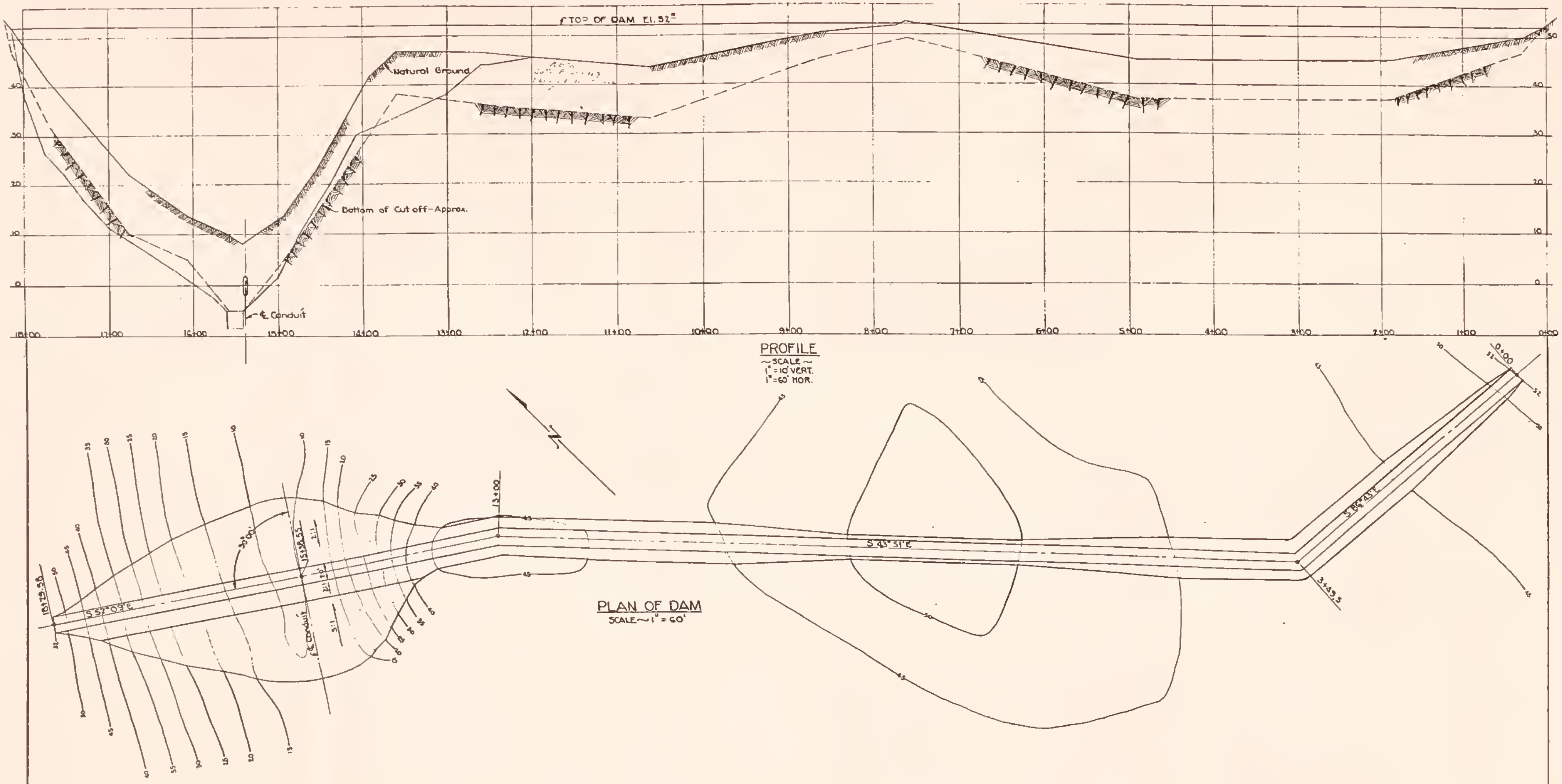


PLAN OF DAM
SCALE~1"=60'



TYPICAL SECTION OF DAM
SCALE~1"=10'
NOTE - THIS SECTION ALSO APPLIES TO NORTH DAM

DETAILS-EAST DAM
NILAN STORAGE PROJECT
LEWIS & CLARK COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA AUG. 1950
DWG. NO. 73-2

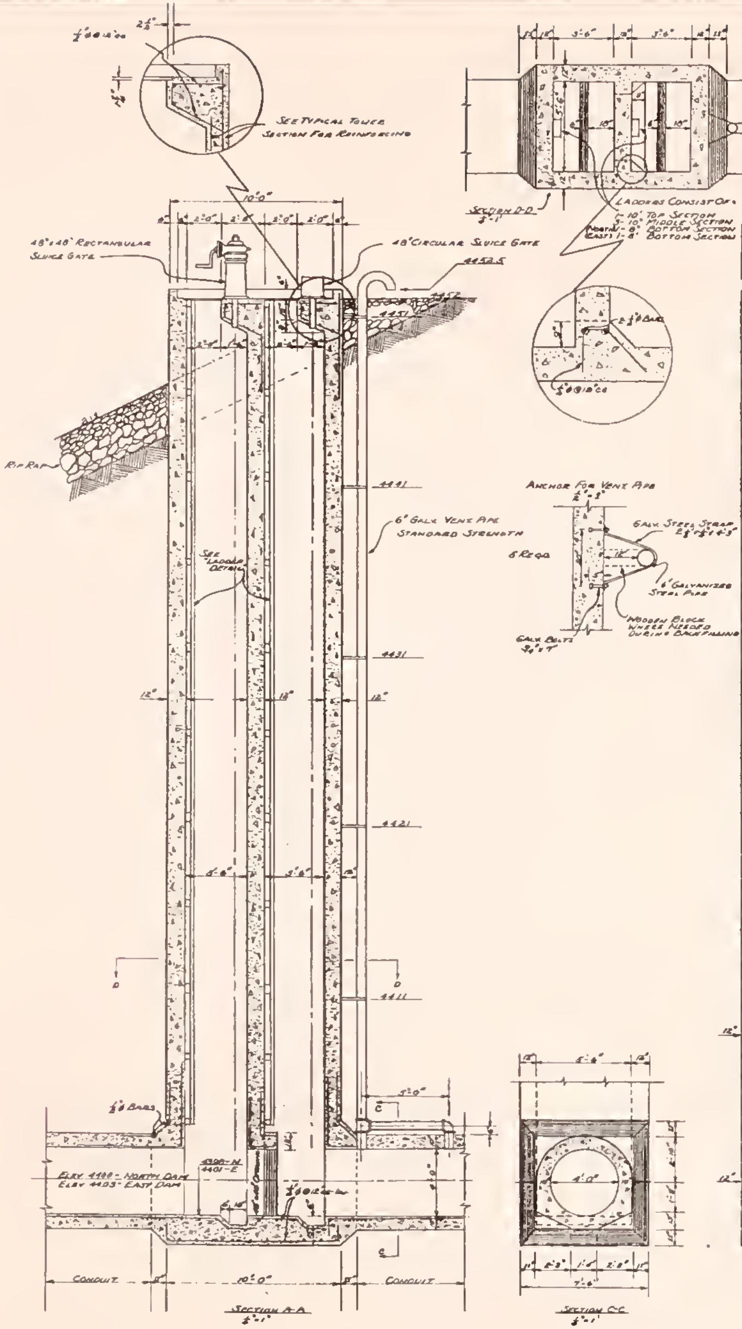


PROFILE
~SCALE~
1" = 10' VERT.
1" = 60' HOR.

PLAN OF DAM
SCALE ~ 1" = 60'

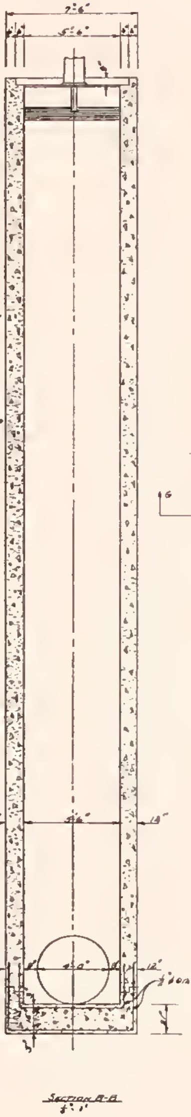
NOTE :-
See Dwg. No. 73-2 for Section of Dam
North & East Dams are similar.

DETAILS-NORTH DAM
NILAN STORAGE PROJECT
LEWIS & CLARK COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA AUG. 1950
DWG. NO. 73-1

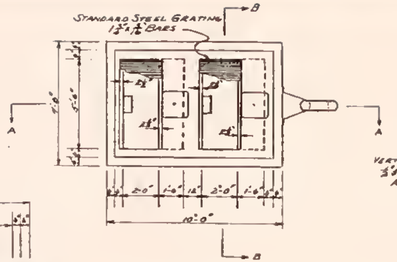


Section A-A
¼"=1'

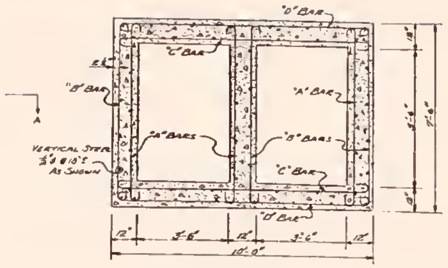
Section C-C
¼"=1'



Section B-B
¼"=1'



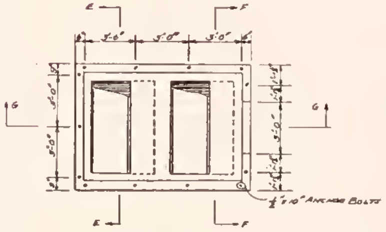
Plan Of Tower
¼"=1'



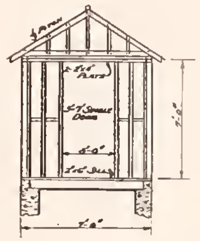
Typical Tower Section
½"=1'

Schedule

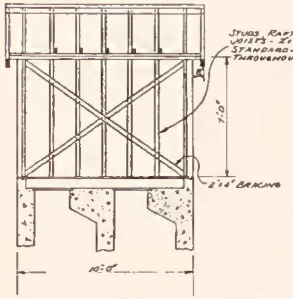
Dam	Elevation	"A" Bars	"B" Bars	"C" Bars	"D" Bars
North East	4398-4403 4401-4403	—	—	½"⌀@7"	½"⌀@10"
Both	4403-4408	½"⌀@5"	½"⌀@7½"	½"⌀@8"	½"⌀@12"
Both	4408-4416	½"⌀@6"	½"⌀@8½"	½"⌀@9½"	½"⌀@12"
Both	4416-4423	½"⌀@7½"	½"⌀@10"	½"⌀@12"	½"⌀@12"
Both	4423-4427	½"⌀@10"	½"⌀@12"	½"⌀@12"	½"⌀@12"
Both	4427-4452	½"⌀@12"	½"⌀@10"	½"⌀@12"	½"⌀@12"



Plan
¼"=1'

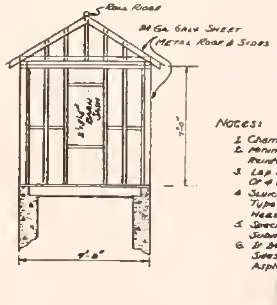


Section F-F
¼"=1'

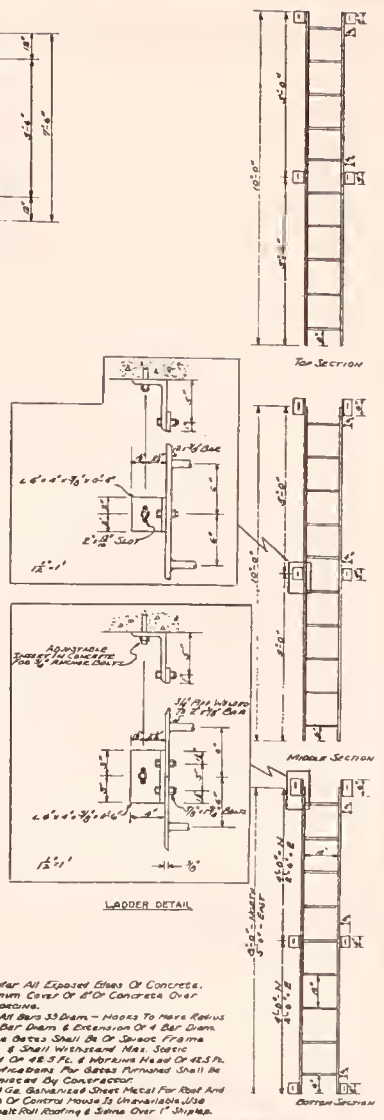


Studs, Rafters & Joists - 2x4" @16"oc Standard Framing Throughout
7'-0"
2"x4" Bracing
10'-0"

Section G-G
¼"=1'



Section E-E
¼"=1'



LADDER DETAIL

Notes:

1. Chamfer All Exposed Edges Of Concrete.
2. Minimum Cover Of 3" Of Concrete Over Reinforcing.
3. Lap All Bars 33 Diam. – Hooks To Have Radius Of 4 Bar Diam. & Extension Of 4 Bar Diam.
4. Sluice Gates Shall Be Of Spigot Frame Type & Shall Withstand Max. Static Head Of 42.5 Ft. & Working Head Of 42.5 Ft.
5. Specifications For Gates Furnished Shall Be Submitted By Contractor.
6. If 24 Ga. Galvanized Sheet Metal For Roof And Sides Of Control House Is Unavailable, Use Asphalt Roll Roofing & Siding Over 1" Shiplap.

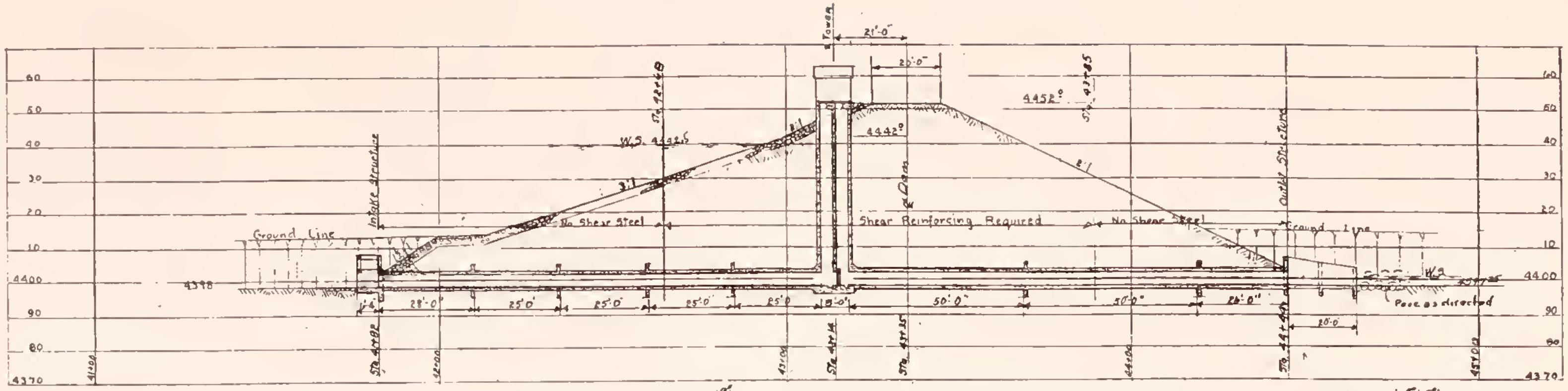
CONTROL WORKS
CONTROL TOWER - DETAILS
NILAN STORAGE PROJECT
LEWIS AND CLARK COUNTY
STATE WATER CONSERVATION BOARD

HELENA, MONTANA
AUGUST, 1950

SCALE AS SHOWN

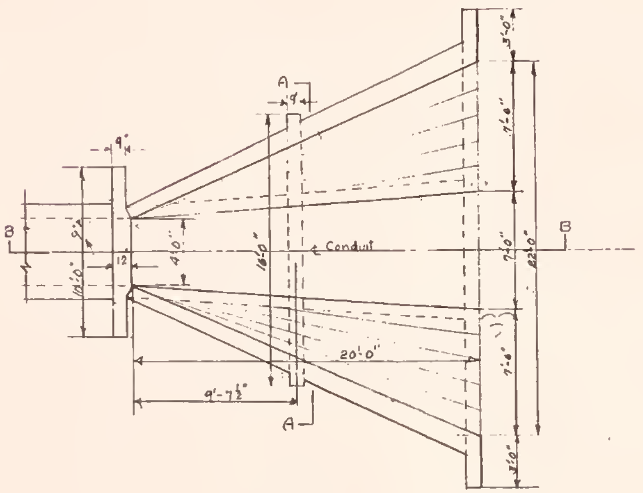
DWG. 31-5

DRAWN BY: R.H.S.

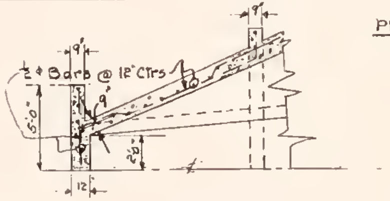


PROFILE ALONG CONDUIT - NORTH DAM

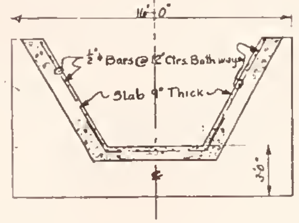
Scale 1" = 20ft.



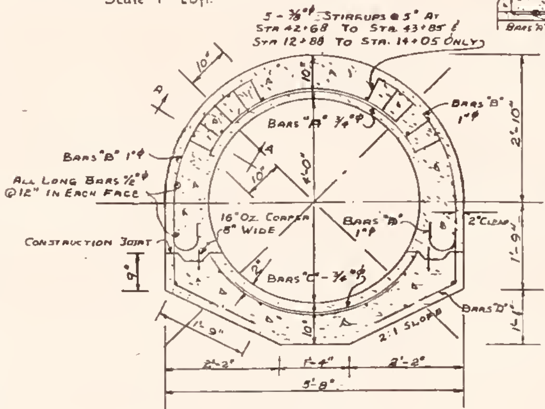
PLAN



SECTION C-C

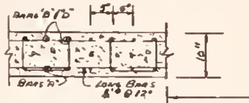


SECTION A-A

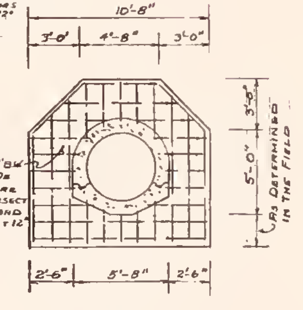


CONDUIT SECTION

¾" = 1'

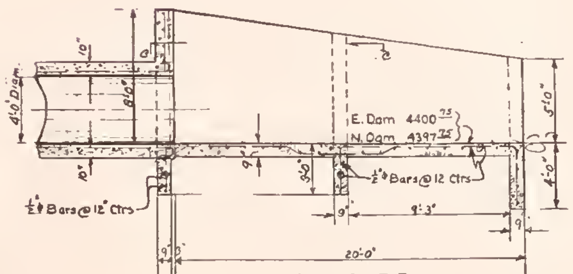


SECTION A-A

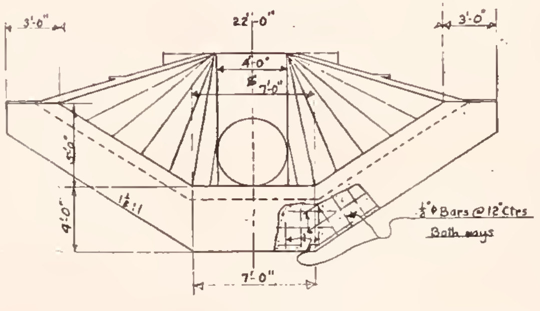

10'-8"
3'-0"
4'-8"
3'-0"
½" ф Bars @ 12" Both In Center Of Cutoff. Where Bars Intersect Conduit, Bend Into Conduit 12"
3'-0"
5'-0"
As Determined In The Field
2'-6"
5'-8"
2'-6"

9" CONDUIT CUTOFF

¼" = 1'



SECTION B-B



END ELEVATION

OUTLET STRUCTURE

Scale ¼" = 1ft.

SCHEDULE OF CONDUIT REINFORCING

North Dam Stationing	East Dam Stationing	"A"-Bars	"B"-Bars	"C"-Bars	"D"-Bars
42+98 - 43+65	13+18 - 13+85	¾" ф @ 5"	1" ф @ 10"	¾" ф @ 6"	1" ф @ 10"
42+68 - 42+98 43+65 - 43+85	12+88 - 13+18 13+85 - 14+05	¾" ф @ 6"	1" ф @ 12"	¾" ф @ 8"	1" ф @ 12"
42+38 - 42+68 43+85 - 44+05	12+58 - 12+88 14+05 - 14+25	¾" ф @ 8"	1" ф @ 20"	¾" ф @ 10"	1" ф @ 20"
42+08 - 42+38 44+05 - 44+25	12+28 - 12+58 14+25 - 14+45	¾" ф @ 10"	1" ф @ 24"	¾" ф @ 12"	1" ф @ 24"
41+82 - 42+08 44+25 - 44+44	12+09 - 12+28 14+45 - 14+59	¾" ф @ 14"	1" ф @ 24"	¾" ф @ 15"	1" ф @ 24"

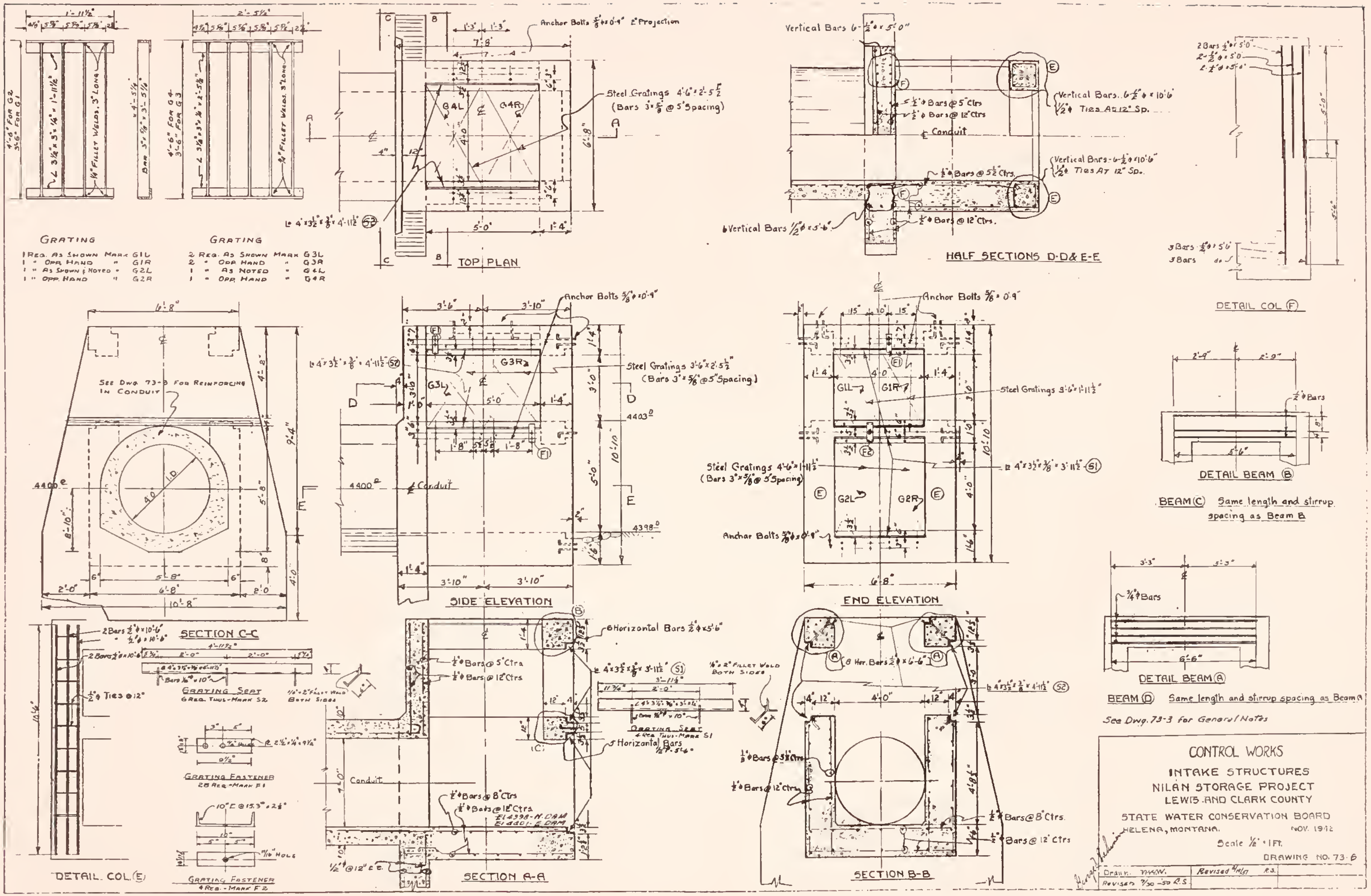
1. "A" Bars Alternate Bars Reverse In Position As Shown Except From Sta. 42+68 To Sta. 43+85, North Dam, And Sta. 12+88 To Sta. 14+05, East Dam; Where Stirrups Are Reqd. And All Bars End 10" Below 45° Line
2. "B" Bars Begin With Hooks At Construction Joint & End 10" Above 45° Line.
3. "C" Bars Alternate Bars Reverse In Position As Shown.
4. "D" Bars Begin Near Invert End And End At 45° Line Except From Sta 42+68 To Sta. 43+85, And Sta. 12+88 To Sta 14+05 Where Stirrups Are Reqd. And All Bars End 10" Above 45° Line
5. All Longitudinal Bars ½" ф @ 12" In Each Face.
6. Stirrups ⅜" ф @ 5" From Sta 42+68 To 43+85 North Dam, And Sta 12+88 To Sta. 14+05, East Dam.
7. 16 Oz. Copper Seal - 8" Wide Shall Be Placed In All Construction Joints.

General Notes:

Chamfer All Exposed Edges Of Concrete 1". Min Cover Of 2" Of Concrete Over Reinforcing. Lap All Bars 33 Diam, Hooks To Have Radius Of 4 Bar Diam. And Extension Of 4 Bar Diam.

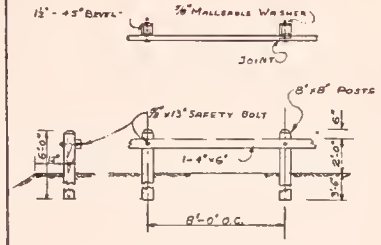
CONTROL WORKS - NORTH DAM
CONDUIT & OUTLET STRUCTURES
NILAN STORAGE PROJECT
LEWIS AND CLARK COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA DEC. 1942
Scale - as shown
DRAWING NO. 73-3

Drawn P.M.W.
Rev 7/28-1950, L.S.

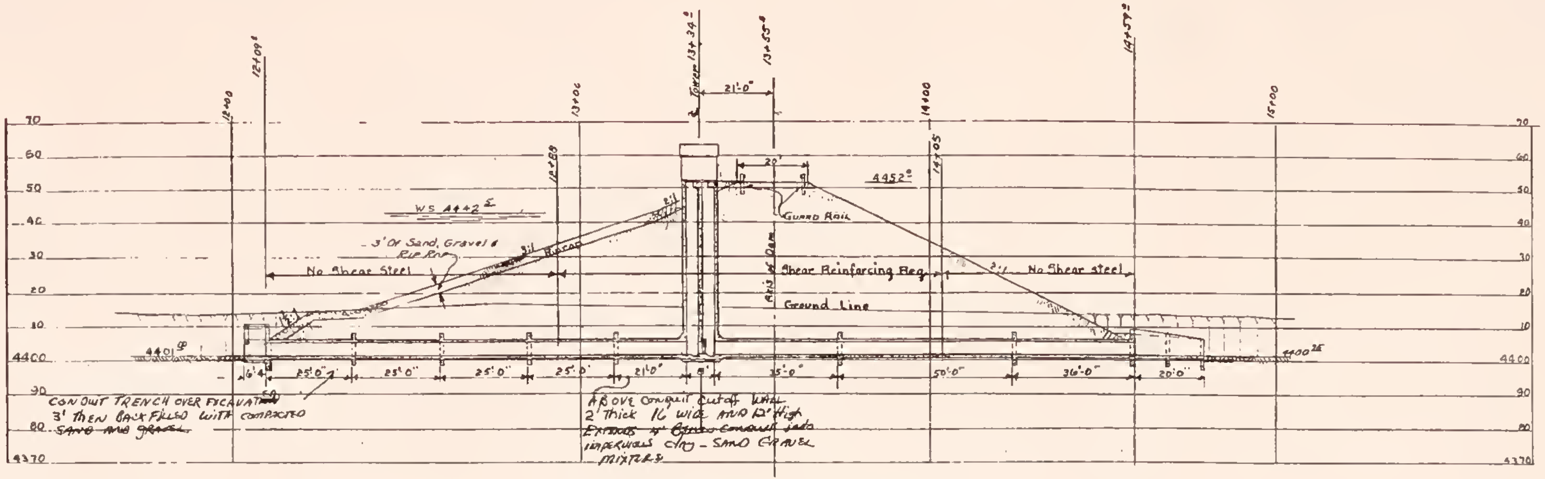

GRATING
1 Req. As Shown Mark G1L
1 " Opp. Hand " G1R
1 " As Shown & Noted " G2L
1 " Opp. Hand " G2R
GRATING
2 Req. As Shown Mark G3L
2 " Opp. Hand " G3R
1 " As Noted " G4L
1 " Opp. Hand " G4R
1/4" Fillet Welds, 3" Long
Bar 3" x 5/8" x 3'-5 1/4"
4'-6" For G2, 3'-6" For G1
4'-6" For G4, 3'-6" For G3
Anchor Bolts 5/8" ϕ x 0'-9" 2" Projection
Steel Gratings 4'-6" x 2'-5 1/2" (Bars 3" x 5/8" @ 5" Spacing)
L 4" x 3 1/2" x 3/8" x 4'-11 1/2" (S2)
G4L
G4R
TOP PLAN
Vertical Bars 6-1/2" ϕ x 5'-0"
1/2" ϕ Bars @ 5" Ctrs
1/2" ϕ Bars @ 12" Ctrs
Conduit
Vertical Bars 6-1/2" ϕ x 10'-6"
1/2" ϕ Ties At 12" Sp.
1/2" ϕ Bars @ 5 1/2" Ctrs.
1/2" ϕ Bars @ 12" Ctrs.
Vertical Bars 1/2" ϕ x 5'-6"
HALF SECTIONS D-D & E-E
2 Bars 1/2" ϕ x 5'-0"
2-1/2" ϕ x 5'-0"
2-1/2" ϕ x 5'-0"
3 Bars 1/2" ϕ x 5'-6"
3 Bars do
DETAIL COL. (F)
See Dwg. 73-3 For Reinforcing In Conduit
4400.0
SECTION C-C
Anchor Bolts 5/8" ϕ x 0'-9"
L 4" x 3 1/2" x 3/8" x 4'-11 1/2" (S2)
Steel Gratings 3'-6" x 2'-5 1/2" (Bars 3" x 5/8" @ 5" Spacing)
G3R
G3L
4403.0
4400.0
Conduit
4398.0
SIDE ELEVATION
Anchor Bolts 5/8" x 0'-9"
Steel Gratings 3'-6" x 1'-11 1/2"
G1L
G1R
Steel Gratings 4'-6" x 1'-11 1/2" (Bars 3" x 5/8" @ 5" Spacing)
L 4" x 3 1/2" x 3/8" x 3'-11 1/2" (S1)
G2L
G2R
Anchor Bolts 5/8" ϕ x 0'-9"
END ELEVATION
1/2" ϕ Bars
DETAIL BEAM (B)
BEAM (C) Same length and stirrup spacing as Beam B
3/4" ϕ Bars
DETAIL BEAM (A)
BEAM (D) Same length and stirrup spacing as Beam A
See Dwg. 73-3 for General Notes
2 Bars 1/2" ϕ x 10'-6"
- 1/2" ϕ x 10'-6"
1/2" ϕ Ties @ 12"
DETAIL COL. (E)
2 Bars 1/2" ϕ x 10'-6"
L 4" x 3 1/2" x 3/8" x 4'-11 1/2"
Bars 3/4" ϕ x 10"
GRATING SEAT
6 Req. This Mark S2
1/4" x 2" Fillet Weld Both Sides
GRATING FASTENER
28 Req. - Mark F1
10" E @ 15.3" x 2 1/2"
11/16" Hole
GRATING FASTENER
4 Req. - Mark F2
6 Horizontal Bars 1/2" ϕ x 5'-6"
1/2" ϕ Bars @ 5" Ctrs
1/2" ϕ Bars @ 12" Ctrs
L 4" x 3 1/2" x 3/8" x 3'-11 1/2" (S1)
GRATING SEAT
4 Req. This Mark S1
5 Horizontal Bars 1/2" ϕ x 5'-6"
1/4" x 2" Fillet Weld Both Sides
Conduit
1/2" ϕ Bars @ 8" Ctrs
1/2" ϕ Bars @ 12" Ctrs
El. 4398 - N. Dam
El. 4401 - E. Dam
1/2" ϕ @ 12" C.C.
SECTION A-A
8 Hor. Bars 3/4" ϕ x 6'-6"
L 4" x 3 1/2" x 3/8" x 4'-11 1/2" (S2)
1/2" ϕ Bars @ 5 1/2" Ctrs.
1/2" ϕ Bars @ 12" Ctrs.
1/2" ϕ Bars @ 8" Ctrs.
1/2" ϕ Bars @ 12" Ctrs
SECTION B-B

CONTROL WORKS
INTAKE STRUCTURES
NILAN STORAGE PROJECT
LEWIS AND CLARK COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA. NOV. 1942
Scale 1/2" = 1 Ft.
DRAWING NO. 73-6

Drawn. W.W.W.	Revised 4/11/51 R.S.	
Revised 7/30-50 R.S.		



Details Of Wood Guard Rail
Scale ~ ½" = 1'

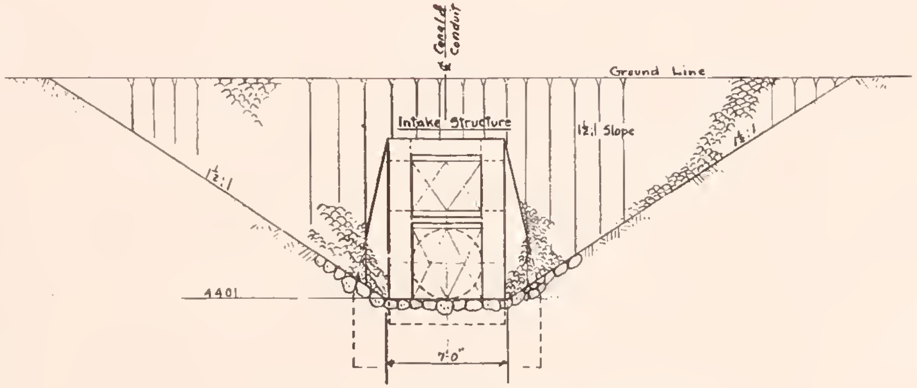


Conduit trench over excavated 3' then backfilled with compacted ~~sand and gravel~~

Above conduit cutoff wall 2' thick 16' wide and 12' high extends 4' ~~[illegible]~~ conduit into impervious clay - sand gravel mixture

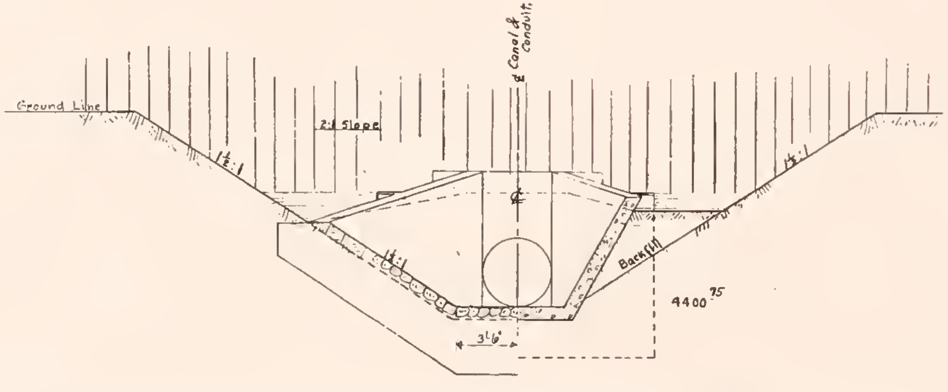
PROFILE ALONG CONDUIT - EAST DAM

Scale 1" = 20ft.



SECTION SHOWING GRADING AT INTAKE

Scale ¼" = 1ft.



HALF SECTION AT END OF OUTLET STRUCTURE

HALF SECTION MIDWAY OF STRUCTURE

SHOWING GRADING AT OUTLET

Scale ¼" = 1ft.

References:

North Dam	Intake Structure	Dwg No 6
	Control Tower	" " 5
	Conduit & Outlet Structure	" " 3

Conduit and Control Tower Details similar to North Dam.

Intake and Outlet Structures same as for North Dam except for Elevation.

CONTROL WORKS
EAST DAM
NILAN STORAGE PROJECT
LEWIS AND CLARK COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA. DEC. 1942
Scale - as shown
DRAWING NO. 73-4
Drawn P.H.W.